Dŵr Cymru Welsh Water

Environmental Assessment of Llyn Bodlyn Drought Order (8033-2)

Final

March 2019

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NON-TECHNICAL SUMMARY

INTRODUCTION AND PURPOSE OF THIS REPORT

Welsh Water's Drought Plan provides a comprehensive statement of the actions Welsh Water will consider implementing during drought conditions to safeguard essential water supplies to customers and minimise environmental impact. It encompasses a number of drought management options that will only be implemented if and when required and includes drought permit / order options.

A drought order or permit is a management action that, if granted, can allow more flexibility to manage water resources and the effects of drought on public water supply and the environment.

The objective of this report is to provide an independent and robust assessment of the potential environmental effects of implementing a drought order at Llyn Bodlyn Reservoir, over and above those arising due to natural effects of drought and those which would occur under "normal" abstraction licence conditions.

Llyn Bodlyn Reservoir is located in Welsh Water's Barmouth WRZ which covers the coastal region from Harlech to Barmouth.

The assessment also considers how the proposed drought order may affect the environment in combination with the effects of other existing abstraction licences, environmental permits and other drought management plans.

This report is a 'shelf-copy' report which would be updated to support an application to Natural Resources Wales (NRW) for a drought order at Llyn Bodlyn, which may be required by Welsh Water in the future.

PROPOSED DROUGHT ORDER DETAILS

In order to protect essential public water supplies within Welsh Water's Barmouth WRZ in the event of a future severe drought, Welsh Water may need to make an application to NRW for a drought order to vary the conditions of its abstraction licence from Llyn Bodlyn.

If granted, the drought order would involve a reduction in the statutory compensation flow release from Llyn Bodlyn to the Afon Ysgethin from 2.18Ml/d to 1.18Ml/d. This would conserve the longevity of reservoir storage for use in direct water supply during a drought. The drought order will potentially influence the downstream Afon Ysgethin.

The timing of the reduction in the compensation flow release is most likely to occur during the late summer / early autumn period, and is considered not to extend outside

the period July to October. This has been confirmed by Welsh Water's water resources modelling.

The revised abstraction arrangements would be authorised for four months but would be removed sooner if water resources have returned to adequate levels to safeguard future water supplies, as agreed with Natural Resources Wales.

NEED FOR THE DROUGHT ORDER

Application for a drought order is a precautionary approach. Due to the time needed to determine a drought order application, Welsh Water will potentially apply for a drought order more frequently than it will be used.

The justification for the drought order sought will be set out in a "Needs Statement". This will be produced by Welsh Water at the time of a potential future application, and will form part of the full drought order application.

ALTERNATIVE SOURCES CONSIDERED

Details of alternative sources considered by Welsh Water will be completed at the time of application for the drought order at Llyn Bodlyn. This will demonstrate justification for the proposed drought option details applied for.

POTENTIAL IMPACTS OF DROUGHT ORDER IMPLEMENTATION

The scope of the assessment has been defined by a screening and scoping exercise.

Summary of the Hydrological Assessment for the Afon Ysgethin

The assessment has concluded that there are **major-moderate** impacts on river flows as a result of implementing the drought order. There are **minor** impacts on the physical environment of the river, including minor impacts for water quality.

Summary of the Environmental Features Screening for the Afon Ysgethin

Environmental assessment is required and included for features where screening has identified a major or moderate impact.

Screening identified Meirionnydd Oakwoods and Bat Sites / Coedydd Derw a Safleoedd Ystlumod Merion SAC and Coed Cors y Gredol SSSI, WFD Status and Community Assessment / Notable Species, invasive fauna and landscape, recreation and archaeology as environmental features for which an environmental assessment was required. The assessment has concluded that there are **major** to **minor** impacts on aquatic ecology specifically: major impacts on fish; moderate impacts on macroinvertebrates and macrophytes; and minor impacts on phytobenthos.

Cumulative Impacts

No cumulative effects of implementing the drought order with existing licences, consents and plans are currently anticipated. However, this should be reviewed at the time of any future application for a drought order at Llyn Bodlyn.

MITIGATION AND MONITORING

The environmental assessment has identified significant impacts of implementation of a drought order at Llyn Bodlyn. Consequently, in line with the DPG, an Environmental Monitoring Plan has been proposed. Potential mitigation measures for fish have also been proposed and further discussion with NRW is required in order to develop suitable mitigation measures.

CONCLUSIONS

In summary, it has been concluded that the environmental effects on river flows, water quality and ecology of implementing a drought order at Llyn Bodlyn, over and above those conditions that already exist under "normal", i.e. licensed, baseline conditions, with the onset of a natural drought, would be **major.**

Contents

1 INTRODUCTION

1.1 PURPOSE OF THE ENVIRONMENTAL ASSESSMENT

The objective of this Environmental Assessment Report (EAR) is to provide an independent and robust assessment of the potential environmental effects of the implementation of a drought order by Dŵr Cymru Welsh Water (Welsh Water) to temporarily modify the abstraction licence conditions to allow a temporary decrease in the compensation flow release. Water abstracted at Llyn Bodlyn is used to provide public water supplies to Welsh Water's Barmouth Water Resource Zone (WRZ)[1] (see Section 2.1).

This EAR is a 'shelf-copy' report which would be updated in the event that Welsh Water needs to make an application during any future drought to Natural Resources Wales (NRW) for a drought order at Llyn Bodlyn. A drought order is a management action that, if granted, can help ensure essential water supplies are maintained to homes and businesses. The circumstances under which a drought order may be required is set out in the Welsh Water Drought Plan.

The assessment presented in this EAR considers the effects of implementation of the drought order over the period July to October. The purpose of the assessment is to determine the environmental impacts of the drought order over and above any effects arising from natural drought conditions.

The study area and focus of this environmental assessment of the Llyn Bodlyn drought order, covers the following waterbodies:

- The Afon Ysgethin to tidal limit (GB110064048830)
- Llyn Bodlyn Reservoir (GB31035561)

This EAR includes discussion of the following:

- an assessment of the likely changes in river flow / water level regime due to implementing the proposed drought order (**for a summary, see Section 4 of this report**)
- identification of the environmental features that are sensitive to these changes and an assessment of the likely impacts on these features (**see Section 5 of this report**)
- identification of mitigation measures that may be required to prevent or reduce impacts on sensitive features (**see Section 6 of this report**)

[1] UKWIR/Environment Agency define a WRZ as: 'The largest possible zone in which all resources, including external transfers, can be shared, and hence, the zone in which all customers will experience the same risk of supply failure from a resource shortfall.'

- recommendations for baseline, in-drought and post-drought order monitoring requirements (**see Section 10 of this report**).

The environmental assessment has been conducted in accordance with Government regulations and using the Welsh Government / Natural Resources Wales Drought Plan Guideline[2] (DPG); specifically, Section 5 and Appendices I and J, and Welsh Government / Defra / NRW / Environment Agency guidance on drought permits and drought orders[3].

Consideration has been given to the potential impacts of drought order implementation on statutory designated sites, including those designated under international law (Habitats Directive, Birds Directive and the Ramsar Convention) and national legislation (notably Sites of Special Scientific Interest (SSSIs)).

In accordance with the DPG, the assessment also considers how the proposed drought order may affect the environment in combination with the effects of existing abstraction licences, environmental permits and other relevant activities and plans. This is discussed further in Sections 3 and 7.

1.2 SUPPORTING STUDIES

The DPG identifies in Section 5.4 that EARs are required as supporting documents to any drought permit or drought order application. The circumstances for which an environmental assessment is required are set out in **Box 1** below.

Box 1: Drought Plan Guidance - requirement for environmental assessment

The DPG requires that all features that could be affected by implementation of a drought order /permit are listed in the EAR and that an assessment is made of how sensitive each feature is to the likely changes in hydrology, hydrogeology and geomorphology, due to implementing the drought order /permit.

The DPG requires a detailed environmental assessment for applications where sensitive features are likely to be subject to a major or moderate impact, or a minor impact where this applies to environmentally designated features. Further environmental assessment is **not** required for those drought orders / permits where there is certainty that there are no such impacted sensitive features.

This environmental assessment is based on data available at the time of writing and includes the environmental features and data types determined by Box 1 in Appendix I of the DPG (except where these are considered not to be relevant to this drought

[2] Natural Resources Wales (2017) *Water Company Drought Plan Technical Guideline*. Available at https://cdn.naturalresources.wales/media/684414/final-wc-drought-plan-guidance-2017.pdf?mode=pad&rnd=131656713580000000, Accessed 04 February 2019.
[3] Welsh Government / Defra / Natural Resources Wales / Environment Agency (2015) *Apply for a drought order or emergency drought order*, https://www.gov.uk/government/collections/apply-for-a-drought-permit-drought-order-or-emergency-drought-order Accessed 21 December 2018.

order). Data were requested from key consultees (including NRW).

Where appropriate, this report also identifies areas where there are deficiencies in data availability and makes recommendations for future data / information gathering and monitoring. Welsh Water will continue to engage closely with NRW to ensure that adequate and sufficient data / information are collated and kept up-to-date in subsequent years to inform future environmental assessments.

1.3 CONSULTATION

Consultation is identified as an essential exercise in the preparation of the EAR. In preparing this 'shelf-copy' EAR for a drought order at Llyn Bodlyn, consultation with regulators and wider stakeholders has been undertaken to gain feedback on potential adverse effects, gather data and discuss any required monitoring and / or mitigation measures.

Further consultation will be also be undertaken at the time of any future applications for the drought order.

1.4 STRUCTURE AND CONTENT OF THE REPORT

This EAR comprises the following sections:

Section 1: Introduction

Section 2: Background to the Drought Order

Section 3: Approach

Section 4: Hydrology and the Physical Environment

Section 5: Environmental Features Assessment

Section 6: Mitigation

Section 7: Cumulative Impacts

Section 8: Summary of Residual Impacts

Section 9: Habitats Regulation Assessment

Section 10: Environmental Monitoring Plan (EMP)

Section 11: Conclusions

2 BACKGROUND TO THE DROUGHT ORDER

2.1 WELSH WATER'S SUPPLY SYSTEM

Welsh Water supplies water to more than 3 million people. The Welsh Water supply area covers the majority of Wales and a small part of England. It is split into 24 WRZ's (see **Figure 2.1)**.

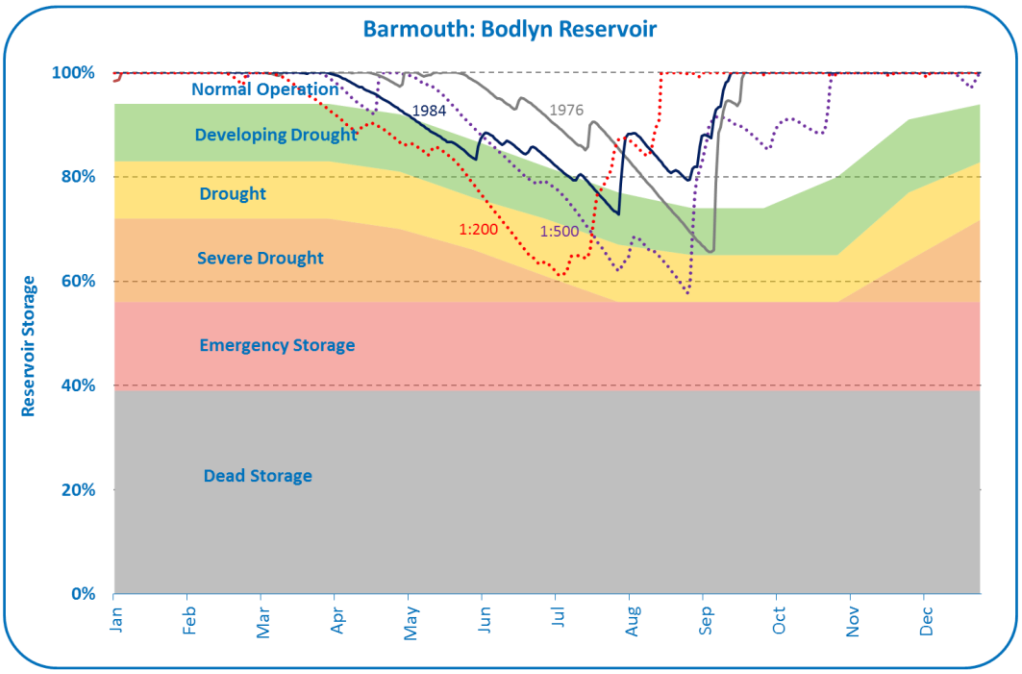
Figure 2.1 Welsh Water Water Resource Zones

The area of Barmouth WRZ covers the coastal region from Harlech to Barmouth. This small WRZ is served from a single impounding reservoir, Llyn Bodlyn, which feeds Eithinfynydd WTW. Peak demands (caused primarily by influxes of tourists) during dry periods often means that the volume of water abstracted from the reservoir approaches the treatment capacity at the works.

The trigger levels for applying for a drought order at Llyn Bodlyn are based on reservoir storage falling below a defined level; this is shown in **Figure 2.2** (dark orange shading

labelled as 'severe drought'). Welsh Water's assessment in its draft Drought Plan 2020 indicates that drought conditions severe enough to require an application for this drought option are unlikely to occur more frequently than at a return period of around once every 200 to 500 years. Fuller details of the work undertaken to assess this risk are provided in Annex 1 to the draft Drought Plan 2020.

Figure 2.2 Llyn Bodlyn Drought Diagram Action Zones and Historic Droughts



2.2 DESCRIPTION OF EXISTING ARRANGEMENTS AT LLYN BODLYN DROUGHT ORDER

Welsh Water's licence (number 23/64/15/9) to abstract water under the Water Resources Act 1991 at Llyn Bodlyn (see **Figure B1.1**) includes the following conditions:

- 980 million litres (Ml) authorised to be abstracted per annum
- At an abstraction rate not exceeding 3.0Ml/d[4], with provision to increase to 3.5 Ml/d on any 14 days during the year
- Subject to the Barmouth Local Board Act 1891, which requires the discharge of compensation water (equivalent to a continuous daily release) of 2.18Ml/d to the Afon Ysgethin.

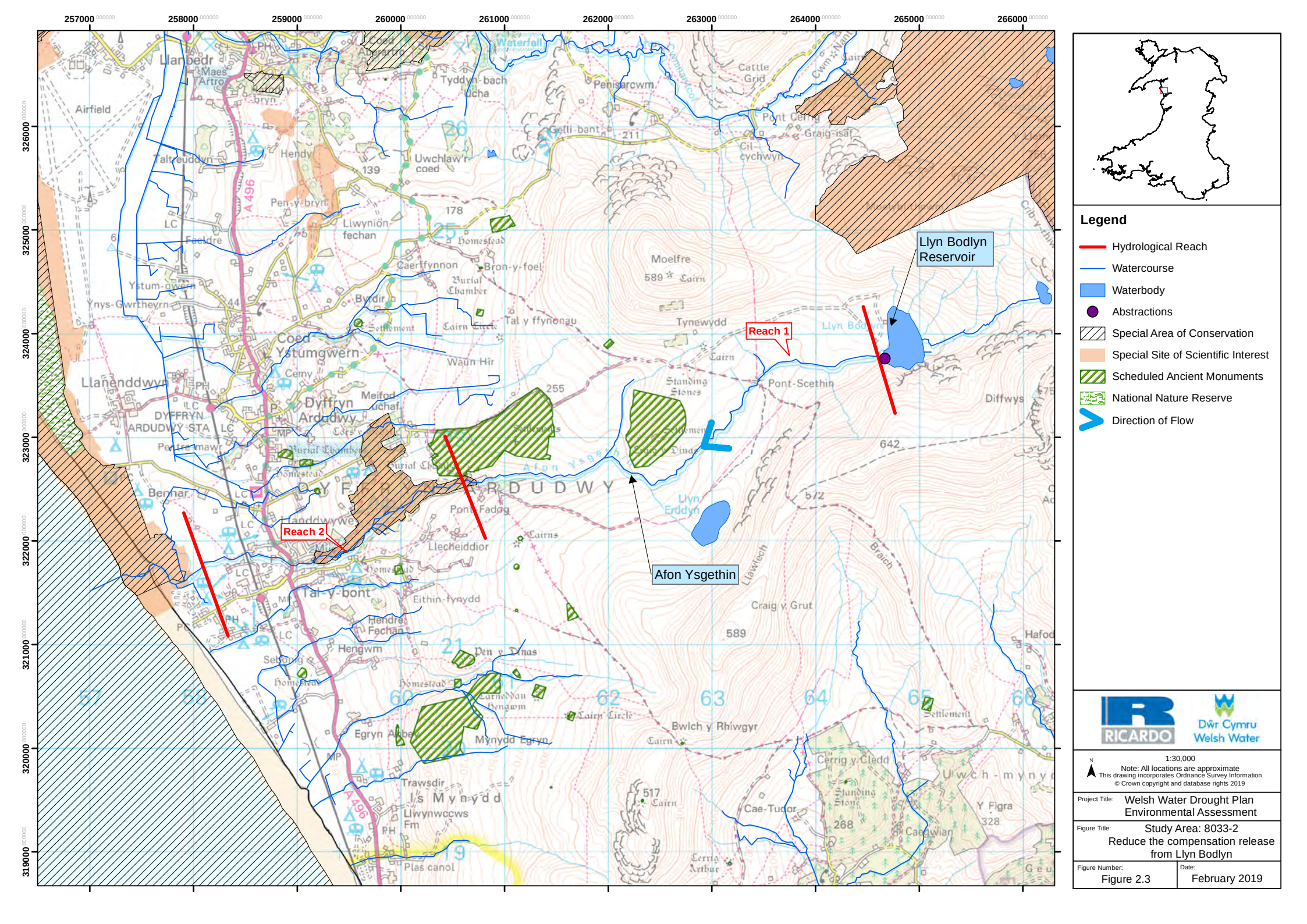
The abstraction for potable supply is made directly from the reservoir and piped 5km by gravity to the local water treatment works (WTW) at Eithynfynydd for treatment

[4] 1Ml/d is 1 million litres per day.

and distribution. Abstraction from the reservoir under gravity can be achieved to a maximum drawdown level of 3.2m below reservoir spillway crest level.

Compensation flow releases are controlled through a notched weir system. When reservoir levels are above the spillway crest level, excess water overflows (spills) from the reservoir to the Afon Ysgethin down a 3m wide spillway channel.

The study area is illustrated on **Figure 2.3**.


Llyn Bodlyn Reservoir
Reach 1
Reach 2
Afon Ysgethin
Legend
Hydrological Reach
Watercourse
Waterbody
Abstractions
Special Area of Conservation
Special Site of Scientific Interest
Scheduled Ancient Monuments
National Nature Reserve
Direction of Flow
RICARDO
Dŵr Cymru Welsh Water
1:30,000
Note: All locations are approximate
This drawing incorporates Ordnance Survey Information
© Crown copyright and database rights 2019
Project Title: Welsh Water Drought Plan Environmental Assessment
Figure Title: Study Area: 8033-2 Reduce the compensation release from Llyn Bodlyn
Figure Number: Figure 2.3
Date: February 2019

2.3 WELSH WATER'S DROUGHT PLANNING PROCESS

Water companies in England and Wales are required to prepare and maintain Statutory Drought Plans under Sections 39B and 39C of the Water Industry Act 1991, as amended by the Water Act 2003, which set out the management and operational steps a water company will take before, during and after a drought. The Water Industry Act 1991 defines a drought plan as '*a plan for how the water undertaker will continue, during a period of drought, to discharge its duties to supply adequate quantities of wholesome water,* with *as little recourse as reasonably possible to drought orders or drought permits*'.

The Drought Direction (Wales) 2017 states that revised Drought Plans should be submitted according to the following schedule:

> *4(b) for a revised drought plan –*
>
> *if section 39B(6)(a) of the Act applies, within 6 months after the date on which the material change of circumstances occurs; and*
>
> *if section 39B(6)(c) of the Act(c) applies, no later than 4 years after the date on which its drought plan, or its last revised drought plan, is published.*

2.4 STATEMENT OF THE NEED FOR DROUGHT ORDER

This section will be completed at the time of application for a drought order.

2.5 DROUGHT ORDER – REGULATORY ARRANGEMENTS

In periods of unusually low rainfall, when water resources become scarce, the Water Resources Act 1991, as amended by the Environment Act 1995 and the Water Act 2003, allows for three mechanisms for temporarily augmenting water supplies from rivers, lakes, reservoirs and groundwaters: drought permits; ordinary drought orders; emergency drought orders.

Drought permits are granted by NRW, and allow a water company powers to abstract from specified water sources, or to modify or suspend the conditions set out in existing abstraction licences. Drought orders are granted by the Welsh Ministers and give powers either to a water company or to NRW to abstract from specified water sources, or to modify or suspend the conditions set out in existing abstraction licences, but also to allow the discharge of water to specified places, modify or suspend conditions relating to a discharge or prohibit or limit particular non-essential uses of water as set out in the Drought Plan (Wales) Direction 2017. Emergency drought orders grant the same powers as a drought order, but in addition, confer powers to prohibit or limit water uses as specified by the water company and allow the set up and supply of water by means of standpipes and/or water tanks or rota cuts.

Drought permits and orders may be granted for a period of up to six months and they can be extended for up to a further six months.

As part of the drought order/permit application process, water companies are required to prepare an Environmental Report setting out anticipated effects of the proposal, including the effect on other abstractors and sufficient information to inform assessments, where applicable, in relation to the Habitats Directive, Countryside and Rights of Way Act (CRoW), and the Water Framework Directive (WFD).

Further information on the requirements for the environmental assessment and reporting according to legislation and national guidance are provided in Section 3.

2.6 REVIEW OF ALTERNATIVE OPTIONS

This section will be completed at the time of application for a drought order, setting out the alternative options to the drought order that Welsh Water has considered in addressing the risks to essential public water supplies due to drought.

2.7 PROPOSED DROUGHT ORDER DETAILS

The drought order involves a proposed reduction in the statutory compensation flow release from Llyn Bodlyn Reservoir to the Afon Ysgethin from 2.18Ml/d to 1.18Ml/d. This would conserve the longevity of reservoir storage for use in direct supply during a drought. The drought order will potentially influence the downstream Afon Ysgethin.

Details of the existing and proposed drought order abstraction at Llyn Bodlyn are presented in **Table 2.1**.

The timing of the reduction in the compensation flow release is most likely to occur during the period from July to October inclusive. This is based on modelling of the Llyn Bodlyn reservoir performance under normal operating conditions in dry summers, together with experience of operating the source. Water resources modelling by Welsh Water using its WRAPSim computer model has indicated that the reduction in compensation flow release would be required for around 12 weeks in drought conditions.

Table 2.1 Llyn Bodlyn Drought Order Existing and Proposed Drought Order Abstraction

Abstraction Water Source	NGR	Normal Abstraction	Proposed drought order Abstraction	Benefit Ml/d
Llyn Bodlyn Reservoir	SH 64670 23760	Welsh Water's licence (23/64/15/9) to abstract water under the Water Resources Act 1991 at Llyn Bodlyn includes the following conditions: • 980 million litres (Ml) authorised to be abstracted per annum • At an abstraction rate not exceeding 3.0Ml/d1 • Subject to the Barmouth Local Board Act 1891, which requires the discharge of compensation water (equivalent to a continuous daily release) of 2.18Ml/d to the Afon Ysgethin.	The drought order involves a proposed reduction in the statutory compensation flow release from Llyn Bodlyn to the Afon Ysgethin by 1 Ml/d, from 2.18 Ml/d to 1.18 Ml/d. This will conserve reservoir storage for use in direct supply during a drought and improve the probability of reservoir winter refill.	1.00

[Note: it will probably be necessary to remove the NGR for any public domain version]

2.8 DROUGHT ORDER PROGRAMME

Drought permits can be granted for a period of up to six months, and they can be extended for up to a further six months. However, the period of implementation for this drought order is restricted to July to October, as confirmed by water resources modelling carried out by Welsh Water.

Prevailing weather conditions and rainfall in the intervening period may delay the requirement for applications, or even result in no requirement to apply. An order may be granted but not actually implemented if weather conditions improve or, equally, the order may only be partially implemented.

2.9 DROUGHT ORDER BASELINE

It is important for the assessment to establish the environmental "baseline" conditions that would exist in drought conditions but in the absence of the drought order being implemented. For the purposes of this assessment, the "without drought order" baseline includes the continuation of abstraction and statutory rate of compensation flow release (2.18Ml/d) under the existing abstraction licence from Llyn Bodlyn Reservoir. This represents normal operating arrangements during a typical summer/autumn period. The assessed drought order assumes a temporary reduction in the compensation rate of 1Ml/d (from 2.18 Ml/d to 1.18Ml/d) to conserve storage in Llyn Bodlyn Reservoir.

3 APPROACH

3.1 INTRODUCTION

The DPG states that the environmental report must include:

i. the likely changes in flow, level, channel/riparian form and sediment due to implementing the action;
ii. the features that are sensitive to these changes;
iii. potential impacts on sensitive features;
iv. a plan of baseline, in-drought and post-drought monitoring; and
v. mitigation or compensation measures that may be required

Items i and ii above were subject to an initial screening process as part of the scoping exercise. Section 3.2 below describes the approach taken. This has provided the relevant study area for the drought order assessment and a list of features scoped into the environmental assessment which are the subject of this EAR.

Section 3.3 describes how the environmental assessment has been undertaken, including discussion of the general approach, guidance used, provision of data, assessment methodologies and consideration of mitigation and monitoring. Limitations to the environmental assessment are described in Section 3.4, 4 and 5.

To set the context of the studies, it should be noted that EAR considers the environmental impacts of implementing a drought order during the worst environmental conditions (natural drought) that the order could be implemented in.

In accordance with the DPG and the Habitats Regulations, the assessment considers how the proposed drought order may affect the environment in combination with the effects of other existing abstraction licences, environment permits and other plans. This includes assessment of the potential cumulative effects of the following:

- Welsh Water's existing abstraction licences that operate within the hydrological zone of influence of the drought option, as well as other abstraction and discharge consents
- Assessment of cumulative impacts of the drought order with other Welsh Water supply side and drought order / permit options within the hydrological zone of influence (including both intra- and inter- zone options)
- Other plans and projects of relevance, including
    - Welsh Water's WRMP schemes which are scheduled to be implemented and become operational within the time period of the revised Drought Plan (i.e. before 2025)

- Drought options from other neighbouring water company Drought Plans, NRW Drought Plans
- National Policy Statements for Wastewater and Renewable Energy Infrastructure.

This is discussed further in Section 7.

3.2 APPROACH TO SCREENING AND SCOPING

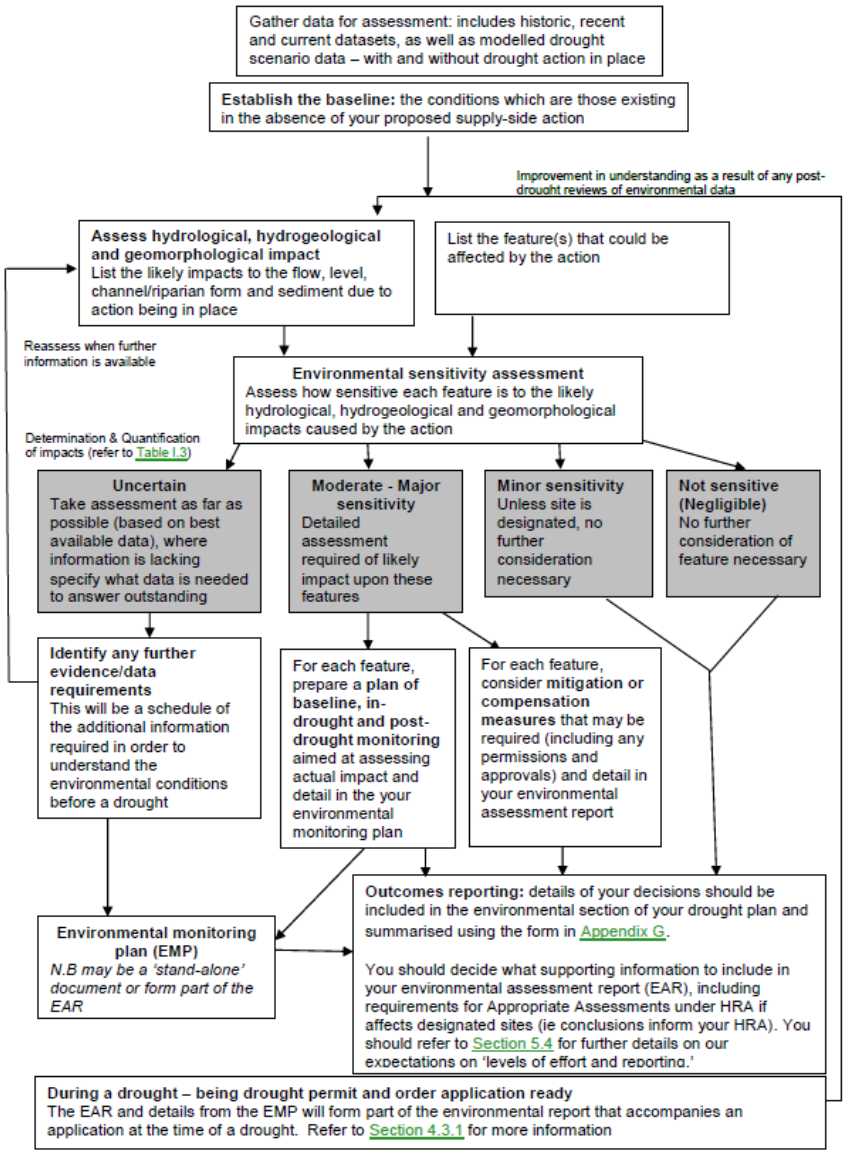
3.2.1 Screening

Screening was undertaken using the DPG; specifically Section 5 and Appendix I. Figure 2 of the DPG (replicated in **Figure 3.1** Environmental Impact Activities Identified in the Drought Plan Guideline

The screening fulfils the requirement to "Assess how sensitive each feature is to the likely hydrological, hydrogeological and geomorphological impacts caused by the action". Stage 1 (hydrological impact) fulfils the requirement to "List the likely impacts to the flow, level, channel/riparian form and sediment due to action being in place". Stage 2 (environmental sensitivity) fulfils the requirement to "list the feature(s) that could be affected by the action" and to "Assess how sensitive each feature is to the likely hydrological, hydrogeological and geomorphological impacts caused by the action"

below) identifies the environmental impact activities required.

Figure 3.1 Environmental Impact Activities Identified in the Drought Plan Guideline



The screening fulfils the requirement to "Assess how sensitive each feature is to the likely hydrological, hydrogeological and geomorphological impacts caused by the action". Stage 1 (hydrological impact) fulfils the requirement to "List the likely impacts to the flow, level, channel/riparian form and sediment due to action being in place". Stage 2 (environmental sensitivity) fulfils the requirement to "list the feature(s) that could be affected by the action" and to "Assess how sensitive each feature is to the likely hydrological, hydrogeological and geomorphological impacts caused by the action"

It is important to acknowledge the basis of the assessment; i.e. impacts of drought order implementation should be considered in the context of what would occur without drought order implementation (see Sections 2.2, 2.7 and 2.9).

The approach to undertaking Stages 1 and 2 is described below.

Stage 1 – Hydrological and Hydrogeological Impact

Consideration is required (by the DPG) of the likely impacts on the hydrology, hydrogeology and geomorphology of every river reach, wetland or lake area influenced by the proposed drought management action, specifically:

- identify the drought conditions which trigger the proposed action;
- identify any changes that the action is likely to bring about, specifying their length, severity and location in relation to existing natural and artificial features;
- describe the likely conditions in the absence of the proposed action;
- describe how the likely conditions would differ with the action in place compared to the same (or analogous) watercourse under natural conditions; and
- identify the extent of the area affected by the planned actions.

The hydrogeological and hydrological information is used together with information on the other environmental features in the study area from Stage 2 - Environmental Sensitivity (see below) to identify the environmental risk of implementing the drought order.

Although the DPG informs the hydrometric data to be used as part of environmental features for consideration within the environmental assessment (see Box 1 Appendix I of the DPG), it does not provide a methodology for identifying the hydrological impact. A bespoke assessment has therefore been undertaken.

The full hydrological assessment approach is set out in **Appendix A**.

The output from these studies provides an understanding of the scale of change in the hydrological characteristics as a result of implementing the drought order. Where changes have been identified, the potential significance of adverse or beneficial impacts has been assessed.

Quantitative and qualitative measures have been used to grade the impacts on surface waters. The assessment has identified the potential severity of impact based on the following criteria:

- **Positive or Negative Impact** – all impacts are considered to be negative unless otherwise stated in the feature assessment.
- **Extent** – the extent of the impact is covered as part of the magnitude consideration.
- **Magnitude** – the magnitude of the impact is identified as**:**

- *High*: There is a long-term large-scale (i.e. catchment) change in the physical environment.
- *Medium*: There is a short-term large-scale change or long-term short-scale (i.e. reach) change in the physical environment, however, no changes in the overall integrity of the physical environment.
- *Low*: There is a short-term small-scale change in the physical environment, but its overall integrity is not impacted.
- *Negligible*: No perceptible change in the physical environment.

- **Duration** – the duration of impact is considered to be for 6 months, which is the duration for which a drought option is implemented, unless otherwise stated.
- **Reversibility** – all hydrological impacts are considered to be reversible**.**
- **Timing and Frequency** – the drought option could be implemented at any point in the year, unless otherwise stated. The assessment is based upon the operation of a single drought order, with subsequent applications for a drought order required to consider cumulative effects of multiple drought orders.
- **Probability** – all impacts are considered to be probable, unless otherwise stated.

The hydrological impact assessment is described fully in **Appendix B**.

Section 4 provides a summary of the hydrology and physical environment assessment as a result of implementing a drought order at Llyn Bodlyn.

Stage 2 - Environmental Sensitivity

With the extent and level of flow impact mapped, using GIS and other data sources, potentially sensitive receptors (sites / features) located within the extents of impact have been identified. Potentially sensitive features investigated in the screening have been drawn from Box 1 in Appendix I of the DPG. These include:

- designated biodiversity sites (Local Nature Reserve (LNR), National Nature Reserve (NNR), Marine Protected Areas, National Parks, Areas of Outstanding Natural Beauty (AONB), SSSI, Special Area of Conservation (SAC), Special Protection Area (SPA), Ramsar) and Environment (Wales) Act Section 7 species / habitats which are located on or within 500m of the impacted reaches;
- protected species;
- ecological communities (fish, bryophytes & lichen, macro-invertebrates, macrophytes, algae) and, where identified, Water Framework Directive (WFD) status of designated waterbodies which contain the impacted reaches;
- invasive non-native species;

- sensitive ecological features as advised by NRW;
- wider features which should be taken into account in determining the potential impacts of drought option implementation – specifically socio-economic & health, amenity & aesthetics, recreation, navigation, architectural & archaeological heritage.

Each of the identified sensitive receptors within the extent of impact have been listed, alongside a brief summary of their potential susceptibility to flow impacts. For designated sites, this has included an indication as to whether the sites have water dependent qualifying interests.

The environmental sensitivity of each site has been identified according to the ecological and nature conservation interests of the area and, in particular, the proximity of and / or connectivity with the designated protected area. Each site has been assessed according to whether the extent of hydrological influence includes or is considered to affect a designated or protected site. Designated or protected sites outside the extent of hydrological influence are considered not to be influenced by the drought order.

The outcome of Stage 1 and Stage 2 of the screening exercise are presented in Sections 4 and 5 respectively.

3.2.2 Scope

The screening exercise establishes the study area for the Llyn Bodlyn drought order together with identification of relevant, sensitive environmental features within those study areas (based on the risk of them being impacted by the drought order during the period of its operation).

As set out in **Figure 3.1**, the environmental sensitivity screening identifies the outcome for each listed feature. Four outcomes are possible from the screening: uncertain; moderate-major sensitivity; minor sensitivity; not sensitive (negligible); and identifies appropriate next steps. Sections 4.2 and 5.2 present the findings which show that a number of features were identified as either: 1) uncertain; 2) moderate-major sensitivity; or 3) minor sensitivity in a designated site and in accordance with the DPG are features for which further assessment work will be required. These features alone form the scope of monitoring, environmental assessment, and consideration of mitigation actions.

The DPG states that environmental assessment, mitigation and / or monitoring is not required for features where screening has identified a minor (unless a site is designated) or negligible impact. However, the requirement for assessment, monitoring and / or mitigation has been reviewed on a case-by-case basis. In some cases, mitigation and / or monitoring has been recommended where minor impacts

are identified, where considered appropriate.

3.3 APPROACH TO ASSESSING IMPACTS, MITIGATION AND MONITORING

3.3.1 General Approach

The assessment approach is in accordance with legislation, national regulations and guidance, including:

- NRW (2017) Water Company Drought Plan Technical Guideline (DPG)
- Welsh Ministers (2017) The Drought Plan (Wales) Direction
- Institute of Environmental Management and Assessment (2004) Guidelines for Environmental Assessment
- Chartered Institute of Ecology and Environmental Management (CIEEM) (2018) Guidelines for Ecological Impact Assessment in the UK and Ireland[5]
- UKWIR (2007, updated 2012) Strategic Environmental Assessment – Guidance for Water Resources Management Plans and Drought Plans. Prepared by Cascade Consulting
- Council Directive 92/43/EEC of 21 May 1992 on the conservation of natural habitats and of wild fauna and flora (Habitats Directive)
- Council Directive 2009/147/EC of 30 November 2009 on the conservation of wild birds
- The Convention on Wetlands of International Importance especially as Waterfowl Habitat , December 1975
- Conservation of Habitats and Species Regulations 2017
- The Countryside and Rights of Way Act 2000.

All aspects of the drought order of potential environmental significance are considered in the environmental assessment.

The DPG states that a water company should clearly show what evidence and data have been used in decision making, that uncertainties should be identified, and which additional data requirements are provided for through the environmental monitoring plan.

In accordance with the DPG the approach to the assessment addresses the following: i) potential effects on each sensitive receptor; ii) definitions for impacts (adverse /

[5] CIEEM, Guidelines for Ecological Impact Assessment in the UK and Ireland: Terrestrial. Freshwater and Coastal. September 2018.

beneficial); iii) the data requirements; iv) assessment methodology (including the treatment of uncertainty where the complete data requirements are not available).

This EAR presents the environmental baseline, i.e. habitats and environmental pressures (including flow and water quality) in the study identified zone of hydrological influence without the drought order in place, utilising a description of the catchment, geomorphology, anthropogenic features and water quality. Key changes to the physical environment as a result of implementing the drought order have been identified and described and, where appropriate, this information is used to frame and support the assessments of features which have been scoped in further to the screening and scoping exercise (see Section 3.2).

3.3.2 Assessment Methodologies

The aim of the Environmental Assessment is to provide:

- A clear summary of the outcome of each assessment (per feature) from which NRW can readily identify the significance of the impact when determining the drought order application.
- Identification of those predicted impacts which are to be taken forward to consider additional monitoring and mitigation actions.

The assessment considers the environmental impacts of implementing the drought order against baseline operating conditions of Welsh Water's abstraction licence in advance of drought order implementation. Environmental sensitivity has been assessed considering the context of the timing of drought order implementation. **It is important to acknowledge the basis of the assessment; i.e. impacts of drought order implementation are assessed against what would occur without drought order implementation**.

The impact assessment for sensitive features is feature specific and is dependent on the availability and resolution of available data. Where possible, quantitative assessments have been undertaken. However, for many features, it is acknowledged that the assessments are qualitative and based on professional judgement, and using, where relevant, experience of local knowledge and reference to literature. This introduces uncertainty into the impact assessment. A precautionary approach has been used to assigning impact significance where data are absent or found not to be robust.

The assessment of impacts on designated sites has been undertaken using professional judgement with reference to conservation objectives and condition status of habitats and species, for which a site has been designated. The ecological assessment has been

undertaken recognising the IEMA[6,7] and the CIEEM study guidelines[8]. The assessment of impacts on other environmental receptors (e.g. recreation and landscape) has been carried out largely by qualitative expert judgement.

Assessment of impacts on specific features has then been undertaken. Specific assessment methodologies have been developed for key environmental features. These are set out in **Appendix C** (assessment methodologies for the ecological assessment of Notable species, designated sites and other flora and fauna).

Other abstractors, including other water company abstractions, are features that have been reviewed within the assessment. This has been undertaken to determine whether other abstractors could potentially be affected by changes to surface water flows and levels as a result of implementation of the drought order.

3.3.3 Mitigation and Monitoring

Section 5.3 of the DPG identifies the specific requirements for mitigation of serious impacts on the environment as a result of implementing a drought management measure. The assessments undertaken in this EAR confirm the features requiring consideration of mitigation and appropriate monitoring triggering mitigation. Appropriate mitigation actions identified are both available and practicable.

The DPG also identifies the specific requirements for monitoring. The assessments undertaken in this EAR inform the features requiring consideration for monitoring prior to, during, or after implementation of the drought order.

The mitigation and monitoring proposals (see Sections 6 and 10) will act as a safeguard that responds and is responsive to both predicted and unpredicted drought impacts. Future data collection and monitoring can then be focused to identify the aquatic ecosystem interaction to better quantify the potential impacts where gaps in the evidence base are identified and ensure the appropriate targeting of monitoring and mitigation response. The EMP will need to be finalised in agreement with NRW.

3.4 LIMITATIONS OF THE ASSESSMENT AND UNCERTAINTIES

The DPG states that a water company should clearly show what evidence and data have been used in decision making, that uncertainties should be identified, and which additional data requirements are provided for through the environmental monitoring plan.

The assessment presented in this document draws on available information from surveys and investigations undertaken by Welsh Water and NRW, as well as other

[6] IEMA (2004) Guidelines for Environmental Impact Assessment.
[7] IEMA (2011) Special Report – The State of Environmental Impact Assessment Practice in the UK
[8] CIEEM (2018) Guidelines for Ecological Impact Assessment in the UK and Ireland.

bodies, over a number of years. Reference has also been made to wider studies from published and grey literature, i.e. academic literature that is not formally published, where appropriate.

Specific details are provided on the quality of the data collected and used in the assessment. Where uncertainties remain with respect to the quantification and prediction of impacts, the limitations and any assumptions made are included in the relevant technical sections (Sections 4 and 5).

Overall, it is considered that the conclusions are based on information that is robust and valid at the time of writing. However, it should be noted that this EAR would be updated to support any future actual application, including a review of data.

4 LLYN BODLYN DROUGHT ORDER - HYDROLOGY AND THE PHYSICAL ENVIRONMENT

4.1 INTRODUCTION

Consideration of hydrology and the water physical environment sets the context for the potential range of environmental effects of the drought order. **Appendix B** sets out an assessment of the potential impacts on the physical environment of Llyn Bodlyn drought order during the period of implementation of the drought order. The "without drought order" baseline is set out in Section 2.9.

The water physical environment assessment includes consideration of hydrology and hydrodynamics; geomorphology; and water quality. The assessment has three key objectives:

1. It is used to "list likely changes in flow, level, channel/riparian form and sediment due to implementing the action' as required by the DPG and set out in Figure 2 of the DPG
2. It is used to support the screening and assessment of sensitive features (including ecological features and designated sites) as required by the DPG and set out in Section 5 of this report
3. Where sensitive features are the physical environment itself, it provides supporting technical information for their screening and assessment.

Each of these are summarised below.

4.2 SUMMARY OF STAGE 1 SCREENING

This fulfils the DPG requirements of Stage 1 of the screening of potential drought order impacts, identifying the likely changes in flow/ level regime due to implementing the drought order. The specific requirements of the DPG are summarised as:

- identify any changes that the drought order is likely to bring about, specifying their length, severity and location in relation to existing natural and artificial features (e.g. flow, water level, channel dynamics and sediment changes);
- describe the likely conditions in the absence of the drought order;
- describe how the likely conditions would differ with the drought order in place compared to the same (or analogous) watercourse under natural conditions; and
- identify the extent of the area affected by your planned actions.

These requirements are addressed in the following sections.

1. The perceived extent of potential impact:

The study area (see **Figure 2.3**) is identified as Llyn Bodln Reservoir and the Afon Ysgethin to its tidal limit.

2. The nature and duration of the potential impact:

A description of the likely conditions with the drought order in place, in comparison to the baseline conditions (absence of the proposed action) is provided in **Appendix B**. Given the conditions of the proposed drought order, the key areas for the assessment of the physical environment have been identified as:

- Change in river flows downstream of Llyn Bodlyn Reservoir.

The **Appendix B** assessment has been summarised in **Table 4.1** in terms of the magnitude and duration of each of these potential physical environment impacts.

3. The length of the potential impact:

The **Appendix B** assessment has been summarised in **Table 4.1** in terms of the timing of each of the potential physical environment impacts. The drought order is most likely to occur during the autumn and winter period, considered to not extend outside the period July to October.

4.3 SUMMARY OF POTENTIAL EFFECTS ON THE PHYSICAL ENVIRONMENT

The potential changes to the physical environment (water quality and geomorphology) due to implementation of the drought order are summarised in **Table 4.1.** These impacts are presented in detail in **Appendix B**.

Table 4.1 Summary of Potential Hydrodynamic and Water Quality Impacts of the Drought Order

Afon Ysgethin (Reach 1)	
Flows in the Afon Ysgethin *Major impacts for up to 12 weeks during the period from July to October inclusive*	• Reductions of up to 46% in river flows with corresponding reductions in wetted depths/wetted widths (potential marginal habitats) during the summer and autumn period.
Water quality in the Afon Ysgethin *Minor risk for up to 12 weeks during the period from July to October inclusive*	• Total ammonia and dissolved oxygen concentrations were all consistent with the standard to support high status for fish and invertebrates throughout the zone of influence of the Llyn Bodlyn drought order.
Surface water abstractions and risk to abstractors *Negligible risk*	• No surface water abstractions
Consented discharges *Negligible risk*	• No consented discharges
Geomorphology *Negligible risk*	• Significant changes considered unlikely.
Afon Ysgethin (Reach 2)	
Flows in the Afon Ysgethin *Moderate impacts for up to 12 weeks during the period from July to October inclusive*	• Reductions of up to 20.4% in river flows with corresponding reductions in wetted depths/wetted widths (potential marginal habitats), during the summer months of July to September; flow reductions of up to 15.2% in October.
Water quality in the Afon Ysgethin *Minor risk for up to 12 weeks during the period from July to October inclusive*	• Total ammonia and dissolved oxygen concentrations were all consistent with the standard to support high status for fish and invertebrates throughout the zone of influence of the Llyn Bodlyn drought order.
Surface water abstractions and risk to abstractors *Negligible risk*	• No surface water abstractions
Consented discharges *Negligible risk*	• Small sewage treatment works - consent limits unavailable, but given physical size of the works it is unlikely to be greater than a negligible risk.
Geomorphology *Negligible risk*	• Significant changes considered unlikely.

4.3.1 Support to the screening and assessment of sensitive features

The assessment included in **Appendix B** has provided information to support the screening and assessment of sensitive features in Section 5. This includes information on short and long term (acute and chronic) direct and indirect, cumulative, and permanent and temporary effects. The assessment is also specific on the difference between the drought order impacts and the baseline condition without a drought order in place.

4.3.2 Supporting technical information for assessment of any physical environment sensitive features

As described in Section 5, several sensitive features relate to the physical environment, rather than ecology or human interaction (e.g. landscape, recreation). The assessment included in **Appendix B** has provided supporting technical information for their screening and assessment in Section 5.

5 LLYN BODLYN DROUGHT ORDER ENVIRONMENTAL FEATURES ASSESSMENT

5.1 INTRODUCTION

As set out in **Box 1** above, environmental sensitivity screening of the drought order was undertaken in line with the approach recommended by the DPG, and scoping undertaken in line with the methodology described in Section 3.2. The screening and scoping has subsequently been reviewed and refined further to discussions and consultation with NRW (see Sections 1.2 and 1.3). The outcome of this process is described in Section 5.2 which shows that a number of features were identified as either: 1) uncertain; 2) moderate-major sensitivity; or 3) minor sensitivity in a designated site. These features form the scope of environmental assessment, which is further described in Section 5.3.

The features assessment is informed by the assessment of the physical environment presented in Section 4 (which includes hydrology, geomorphology and water quality) and identifies the significance of any potential impacts. Consideration of mitigation actions and monitoring is described in Sections 6 and 10 respectively.

Points of interest referred to throughout the text in Section 5 are indicated on **Figure 2.3**.

5.2 SUMMARY OF STAGE 2 SCREENING AND SCOPING

5.2.1 Designated Sites, Notable Species and Other Sensitive Fauna and Flora

In accordance with the DPG, **Table 5.1** identifies designated biodiversity sites (including LNR, NNR, SSSI, SAC, SPA), Environment (Wales) Act Section 7 species / habitats and other sensitive receptors that could be affected by the drought order. Susceptibility to the flow / level impacts resulting from the drought order (see Section 4) is identified according to whether interest features of the site or the species are water dependent. Sensitivity is then determined according to professional judgment based on susceptibility and the level of hydrological impact at the location.

Table 5.1 Designated Sites, Notable Species and Other Sensitive Receptors within the Zone of Influence of the Llyn Bodlyn Drought Order

Site/Feature and designation	Hydrological Impact at Location (Major, Moderate, Minor)	Susceptibility to flow and level impacts	Sensitivity (Uncertain, Moderate/ Major, Minor, Negligible)	Further Consideration Required (Yes/No)
Coed Corsy Gredol SSSI	Moderate (Reach 2)	The site is designated for its important woodland flora including ferns, lichens, mosses and bryophytes which thrive in the humid conditions of the woodland. These features are likely to be sensitive to any reduction in humidity which may be associated with the drought order implementation.	**Moderate**	Yes
Coedydd Derwa Safleoedd Ystlumod Meirion/Meirionnydd Oakwoods and Bat Sites SAC	Moderate (Reach 2)	The site is a very large example of old sessile oak woods in north Wales, with an outstanding Atlantic flora of bryophytes and lichens. It also includes probably the most extensive area of alder *Alnus glutinosa* alluvial forest in north Wales. The features for which the site is designated can be water dependant and may be sensitive to changes in flow and level in the Afon Ysgethin.	**Moderate**	Yes
Llyn Bodlyn Reservoir				
Notable Species – Macrophytes Water plantain *Luronium natans*	Minor Beneficial	The reach is important for floating water-plantain species. The species is restricted to Llyn Bodlyn Reservoir so will not be negatively impacted by the drought order.	**Negligible**	No
Reaches 1 and 2 - Afon Ysgethin				
Benthic macroinvertebrate communities	Major/ Moderate	The moderate to major hydrological impacts are anticipated to reduce the availability of habitats or lead to exposure of benthic macroinvertebrate habitats and reduce habitat suitability by altering habitat suitability for flow sensitive species.	**Moderate**	Yes
Notable species – Invertebrates White clawed crayfish *Austropotamobius pallipes*	Major/ Moderate	No records of white clawed crayfish have been identified for the Afon Ysgethin or Llyn Bodlyn, as such it is assumed to be absent from the catchment and not considered further.	**Negligible**	No
Notable Species – Fish Arctic charr *Salvelinus alpinus* Brown trout *Salmo trutta* Atlantic salmon *Salmo salar* Sea lamprey *Petromyzon marinus* Brook lamprey *Lampetra planeri* River lamprey *Lampetra fluviatilis* Bullhead *Cottus gobio*	Major/ Moderate	A number of notable species occur in the affected reaches (including Llyn Bodlyn reservoir). Changes to velocity, depth, wetted width in the river reaches may restrict the access of migratory fish to spawning tributaries or to dry spawning gravels. Reductions in flow may have short term impacts on habitat and availability for the resident fish community. There will be a minor beneficial impact on water levels in Llyn Bodlyn reseservoir and consequently there is unlikely to be any impacts on fish (including Arctic charr) within the reservoir.	**Major** **(Minor beneficial for fish in Llyn Bodlyn reservoir)**	Yes (No for fish in Llyn Bodlyn reservoir, including Arctic charr)

Site/Feature and designation	Hydrological Impact at Location (Major, Moderate, Minor)	Susceptibility to flow and level impacts	Sensitivity (Uncertain, Moderate/ Major, Minor, Negligible)	Further Consideration Required (Yes/No)
Notable Species – Mammals Lesser horseshoe bat *Rhinolophus hipposideros* Otter *Lutra lutra*	Major/ Moderate	The area includes most of the known maternity roosts in Meirionnydd and some hibernacula, and comprises the centre of distribution for lesser horseshoe bats in Wales. Bats are not water-dependant and will therefore not be affected by either the drought or conditions associated with the drought order. Otter are also known to frequent the study area, and are dependent on the water environment using it as a habitat for foraging, migration and resting. However, no known breeding sites have been identified.	**Negligible**	No
Invasive flora – Japanese knotweed *Fallopia japonica* Giant hogweed *Heracleum mantegazzianum* Himalayan balsam *Impatiens glandulifera*	Major/ Moderate	Invasive plant species utilise flow of the watercourse for dispersal but are not reliant on it. Implementation of the drought order is unlikely to increase the risk of dispersal of invasive plant species.	**Negligible**	No
Landscape and visual amenity	Major/ Moderate	The reach falls into the Meirionnydd area, a mountainous area with deep valleys, wide estuaries and extensive sandy beaches. The study area lies within the Snowdonia National Park and is of high overall landscape and visual amenity value. Reduction in water levels directly affects the landscape and visual amenity value of the site, although this will only be temporary, and will be ameliorated once the drought has passed.	**Uncertain**	Yes
Recreation	Major/ Moderate	Recreational activities are primarily sports orientated with several canoeing, yachting, angling and diving clubs as well as a few outdoor pursuit centres. The area is also attractive for walkers. Any change to the reservoir levels and any reduction in compensation releases to the river may influence the water-dependent activities due to changes in flow. However, water levels will be naturally low in times of drought, and impacts will be temporary in nature.	**Uncertain**	Yes
Archaeology	Major/ Moderate	5 scheduled ancient monuments. 1 prehistoric hillfort, 1 prehistoric enclosed hut circle, 1 prehistoric chambered long cairn, 1 medieval deserted rural settlement and 1 post-medieval/modern bridge.	**Uncertain**	Yes

5.2.2 WFD Waterbody Status

Table 5.2 identifies the WFD Status classification of the WFD waterbodies that may be impacted by implementation of the drought order. Waterbodies classified as overall high / good status / potential, and / or high / good ecological status for fish or macroinvertebrates are likely to be more sensitive to flow impacts. **Table 5.2** summarises the risk to WFD status and indicates where further assessment has been carried out as reported in Section 5.3 below.

Table 5.2 WFD Status Classifications

Waterbody	**Llyn Bodlyn – GB31035561**		**Ysgethin – GB110064048830**	
Hydrological Impact at Location (Major, Moderate, Minor, Negligible)	Minor Beneficial		Major/Moderate	
Heavily Modified Waterbody (Y/N)	Y		Y	
RBMP2 Cycle	RBMP2 (2015)[9]	2018 Cycle 2 Interim Classification[10]	RBMP2 (2015)	2018 Cycle 2 Interim Classification
Overall Biological	Moderate	Moderate	Moderate	Good
Fish	Not classified	Not classified	High	High
Macrophytes	Good	High	Not classified	Not classified
Phytobenthos	High	High	Not classified	Not classified
Macro-invertebrates	Good	Moderate (littoral)	Not classified	Not classified
Phytoplankton	High	Good	Not classified	Not classified
Total P/ Phosphate	High	High	High	High
Ammonia	High	Not classified	High	High
Dissolved Oxygen	Good	Good	High	High
pH	Not classified	Not classified	High	High
Sensitivity (Uncertain, Moderate/ Major, Minor, Not sensitive)	Not Sensitive		Moderate	
Further Consideration Required (Y/N)	No		Yes	

5.3 FEATURES ASSESSMENT

5.3.1 Basis of Features Assessment

This section describes and assesses the potential impacts on the sensitive features during the period of implementation of the drought order.

Based on the sensitive features identified in Section 5.2.1, the degree of impact has been assessed and analysed in Section 5.3. Desk-based assessments have been completed for each of the sensitive receptors, where applicable, in order to determine the magnitude of impact in the Llyn Bodlyn drought order hydrological zone of impact. Each feature assessment describes the analyses carried out and a statement of the

[9] NRW (2017) https://drive.google.com/file/d/0B2hsDbbdxz1tZHItRU9lNkg1YWs/view.
[10] NRW (2018) https://drive.google.com/file/d/14w17jL05sNuToVELqMCK_yc6DdHU7STb/view

assessed impact. All impacts are considered to be negative / adverse unless otherwise stated in the feature assessment. The approach is described in Section 3.3.

5.3.2 Summary of Features Assessment

Table 5.3 presents the overall summary of the significance of potential impacts of the drought order identified from the assessment of designated sites and other ecologically significant receptors and their relevant reaches. Full details of the features assessment are provided in **Appendix D**. A brief summary of the features assessment is also provided below in Sections 5.3.3 – 5.3.8.

Table 5.3 Summary of Impacts of Drought Order Implementation Pre-Mitigation

Month			J	F	M	A	M	J	J	A	S	O	N	D
Reach 1 – Afon Ysgethin (Llyn Bodlyn Reservoir Outflow to Pont Fadog)														
Macrophytes		Macrophyte community	N/A	N/A	N/A	N/A	N/A	N/A					N/A	N/A
Risk to WFD waterbody macrophyte status			N/A	N/A	N/A	N/A	N/A	N/A					N/A	N/A
Macroinvertebrate community			N/A	N/A	N/A	N/A	N/A	N/A					N/A	N/A
Risk to WFD waterbody macroinvertebrate status			N/A	N/A	N/A	N/A	N/A	N/A					N/A	N/A
Fish	European eel	Migration of silvers	N/A	N/A	N/A	N/A	N/A	N/A	N	N			N/A	N/A
	Brown trout	Water quality	N/A	N/A	N/A	N/A	N/A	N/A					N/A	N/A
		Spawning and juvenile habitat	N/A	N/A	N/A	N/A	N/A	N/A					N/A	N/A
Risk to WFD waterbody fish status			N/A	N/A	N/A	N/A	N/A	N/A					N/A	N/A
Phytobenthos			N/A	N/A	N/A	N/A	N/A	N/A					N/A	N/A
Risk to WFD waterbody phytobenthos status			N/A	N/A	N/A	N/A	N/A	N/A					N/A	N/A
Landscape			N/A	N/A	N/A	N/A	N/A	N/A	N/A	N	N	N	N/A	N/A
Recreation			N/A	N/A	N/A	N/A	N/A	N/A	N/A	N	N	N	N/A	N/A
Archaeology			N/A	N/A	N/A	N/A	N/A	N/A	N/A	N	N	N	N/A	N/A
Reach 2 – Afon Ysgethin (Pont Fadog to tidal limit)														
Meirionnydd Oakwoods and Bat Sites SAC			N/A	N/A	N/A	N/A	N/A	N/A					N/A	N/A
Coed Cors y Gredol SSSI			N/A	N/A	N/A	N/A	N/A	N/A					N/A	N/A
Macrophytes		Macrophyte community	N/A	N/A	N/A	N/A	N/A	N/A					N/A	N/A
		Bryophytes	N/A	N/A	N/A	N/A	N/A	N/A					N/A	N/A
Macroinvertebrate community			N/A	N/A	N/A	N/A	N/A	N/A					N/A	N/A
Fish	Atlantic salmon	Adult migration	N/A	N/A	N/A	N/A	N/A	N/A	N	N	N		N/A	N/A
		Water quality	N/A	N/A	N/A	N/A	N/A	N/A					N/A	N/A
		Spawning and juvenile habitat	N/A	N/A	N/A	N/A	N/A	N/A					N/A	N/A
	Brown trout, sea trout	Adult migration	N/A	N/A	N/A	N/A	N/A	N/A	N	N	N		N/A	N/A
		Water quality	N/A	N/A	N/A	N/A	N/A	N/A					N/A	N/A
		Spawning and juvenile habitat	N/A	N/A	N/A	N/A	N/A	N/A					N/A	N/A
	European eel	Migration of silvers	N/A	N/A	N/A	N/A	N/A	N/A	N	N			N/A	N/A
Phytobenthos			N/A	N/A	N/A	N/A	N/A	N/A					N/A	N/A
Landscape			N/A	N/A	N/A	N/A	N/A	N/A	N	N	N	N	N/A	N/A
Recreation			N/A	N/A	N/A	N/A	N/A	N/A	N	N	N	N	N/A	N/A
Archaeology			N/A	N/A	N/A	N/A	N/A	N/A	N	N	N	N	N/A	N/A

Key to Environmental Effects:

N/A	Outside implementation period
N	Negligible impacts are considered likely
	Minor adverse impacts are considered likely
	Moderate adverse impacts are considered likely
	Major adverse impacts are considered likely
	Potential minor beneficial impacts are considered likely
	Potential moderate beneficial impacts are considered likely

5.3.3 Designated Sites

Table 5.4 presents a summary of the potential impacts of the drought order identified from the assessment of designated sites. The location of each of the designated sites discussed below is set out in **Figure 2.3**.

Table 5.4 Summary of Impacts of Drought Order Implementation on Designated Sites

Feature	Impact	Significance of Impact
Reach 2 – Afon Ysgethin		
Meirionnydd Oakwoods and Bat Sites SAC	• Reduction in flows resulting in potential changes to splash zone and humidity affecting bryophyte and lichen communities associated with and immediately adjacent to the river.	**Minor**
Coed Corsy Gredol SSSI	• Reduction in flows resulting in potential changes to splash zone and humidity affecting bryophyte and lichen communities associated with and immediately adjacent to the river.	**Minor**

5.3.4 WFD and Community Assessment

This section considers the potential impact on the feature community within each reach as well as identifying the risk of deterioration in status / potential under the WFD.

WFD Definitions

The following definitions are provided for the determination of status under the WFD.

High ecological status - the values of the biological quality elements for the surface water body reflect those normally associated with that type under undisturbed conditions and show no, or only very minor, evidence of distortion.

Good ecological status - the values of the biological quality elements for the surface water body type show low levels of distortion resulting from human activity, but deviate only slightly from those normally associated with the surface water body type under undisturbed conditions.

Moderate ecological status - the values of the biological quality elements for the surface water body type deviate moderately from those normally associated with the surface water body type under undisturbed conditions. The values show moderate signs of distortion resulting from human activity and are significantly more disturbed than under conditions of good status.

Poor ecological status - waters showing evidence of major alterations to the values of the biological quality elements for the surface water body type and in which the

relevant biological communities deviate substantially from those normally associated with the surface water body type under undisturbed conditions, shall be classified as poor.

Bad ecological status - waters showing evidence of severe alterations to the values of the biological quality elements for the surface water body type and in which large portions of the relevant biological communities normally associated with the surface water body type are absent, shall be classified as bad.

Good ecological potential - there are slight changes in the values of the relevant biological quality elements as compared to the values found at high ecological potential.

Moderate ecological potential - there are moderate changes in the values of the relevant biological quality elements as compared to the values found at maximum ecological potential.

The Environment Agency[11] identify that a number of different factors need be considered when making an assessment of the ecological potential of HMWBs. Of primary importance is the need to put a specified range of mitigation measures in place to address the effects of the anthropogenic impact. Selected ecological quality elements may also be required to be at GES for the waterbody to be classified as GEP. Where the designated use includes for impacts on flow and flow-related mitigation measures the measured status of the fish and macroinvertebrate communities do not affect the classification of GEP.

Assessment

A summary of the potential impacts of the drought order on macrophyte, macroinvertebrate, phytobenthos and fish communities and WFD status is presented below. Full details, including detailed baseline information, can be found in **Appendix D**.

[11] Environment Agency (2011) Method statement for the classification of surface water bodies v2.0 (external release) Monitoring Strategy v2.0 July 2011

Macrophytes

Table 5.5 presents a summary of the potential impacts of the drought order identified from the assessment of macrophytes.

Table 5.5 Summary of Impacts of Drought Order Implementation on Macrophytes

WFD Waterbody		Significance of Impact
Afon Ysgethin waterbody (GB110064048830) Current status: Not classified	• Not assessed	**N/A**
Feature	**Impact**	**Significance of Impact**
Reach 1 – Afon Ysgethin (Llyn Bodlyn Reservoir Outflow to Pont Fadog)		
Macrophytes	• Reduction in growth as a result of major impacts on water levels and flows. • Changes to community composition due to changes to flow rates and habitat loss due to reduction in wetted width. • Increase in filamentous algae levels due to increased nutrients or water temperature and decreased velocity.	**Moderate**
Reach 2 – Afon Ysgethin (Pont Fadog to tidal limit)		
Macrophytes	• Reduction in growth as a result of moderate impacts on water levels and flows. • Changes to community composition due to changes to flow rates and habitat loss due to reduction in wetted width. • Increase in filamentous algae levels due to increased nutrients or water temperature and decreased velocity.	**Minor**
Bryophytes (including *Porella pinnata, Platyhypnidium lusitanicum and Heterocladium wulfsbergii*)	• Changes to inundation pattern, splash and humidity due to changes in flow • Increase in competition from filamentous algae due to increased nutrients or water temperature and decreased velocity.	**Minor**

Macroinvertebrates

Table 5.6 presents a summary of the potential impacts of the drought order identified from the assessment of macroinvertebrates.

Table 5.6 Summary of Impacts of Drought Order Implementation on Macroinvertebrates

WFD Waterbody		**Significance of Impact**
Afon Ysgethin waterbody (GB110064048830) Current status: Not assessed	• Not assessed	**N/A**
Feature	**Impact**	**Significance of Impact**
Reach 1 – Afon Ysgethin (Llyn Bodlyn Reservoir Outflow to Pont Fadog)		
Macroinvertebrates	• Reduction in species diversity as a result of the loss of flow-sensitive taxa. • Loss of marginal habitats and reduction in abundance and distribution of species utilising such habitats. • Reduction in species diversity and abundance as a result of reduced recruitment.	**Moderate**
Reach 2 – Afon Ysgethin (Pont Fadog to tidal limit)		
Macroinvertebrates	• Reduction in species diversity as a result of the loss of flow-sensitive taxa. • Loss of marginal habitats and reduction in abundance and distribution of species utilising such habitats. • Reduction in species diversity and abundance as a result of reduced recruitment.	**Minor**

Fish

Table 5.7 presents a summary of the potential impacts of the drought order identified from the assessment of fish.

Table 5.7 Summary of Impacts of Drought Order Implementation on Fish

WFD Waterbody		**Significance of Impact**
Afon Ysgethin waterbody (GB110064048830) Current status: High	• There is a risk of short-term deterioration in status of the fish component due to the drought order.	**Major**
Feature	**Impact**	**Significance of Impact**
Reach 1 – Afon Ysgethin (Llyn Bodlyn Reservoir Outflow to Pont Fadog)		
European eel	• Migration of silvers	**Moderate** (September-October only
Brown trout	• Reduced water quality	**Minor**
	• Reduction in spawning and juvenile survival due to habitat loss.	**Major**
Reach 2 – Afon Ysgethin (Pont Fadog to tidal limit)		
Atlantic salmon	• Delays and potential cessation of adult migration due to reduced flows.	**Minor** (October only)
	• Reduced water quality.	**Minor**
	• Loss of spawning and juvenile habitat as a result of reduced river levels.	**Moderate**
Brown/sea trout	• Delays of adult sea trout migration due to reduced flows.	**Moderate** (October only)
	• Reduced water quality	**Minor**
	• Reduction in spawning and juvenile survival due to habitat loss.	**Moderate**
European eel	• Migration of silvers	**Minor** (September-October only

Phytobenthos

Table 5.7 presents a summary of the potential impacts of the drought order identified from the assessment of phytobenthos.

Table 5.7 Summary of Impacts of Drought Order Implementation on Phytobenthos

WFD Waterbody		Significance of Impact
Afon Ysgethin waterbody (GB110064048830) Current status: Not assessed	• Not assessed	**N/A**
Feature	**Impact**	**Significance of Impact**
Reach 1 – Afon Ysgethin (Llyn Bodlyn Reservoir Outflow to Pont Fadog)		
Phytobenthos	• Change in community structure due to decreases in velocity, changes to grazing pressure, increases in water temperature, and increases in filamentous algae smothering the substrate. Communities are expected to recover rapidly following return to the normal hydrological regime.	**Minor**
Reach 2 – Afon Ysgethin (Pont Fadog to tidal limit)		
Phytobenthos	• Change in community structure due to decreases in velocity, changes to grazing pressure, increases in water temperature, and increases in filamentous algae smothering the substrate. Communities are expected to recover rapidly following return to the normal hydrological regime.	**Minor**

5.3.5 Landscape, Heritage and Recreation

Table 5.8 presents a summary of the potential impacts of the drought order identified from the assessment of landscape and recreation.

Table 5.8 Summary of Impacts of Drought Order Implementation on Landscape, Heritage and Recreation

Feature	Impact	Significance of Impact
Landscape	• Landscape and visual amenity impacts may be visible from public rights of way, footpaths, cycle routes and river crossings. However, the impact on flows will only be temporary and will be ameliorated once the drought has passed. • Flows during drought conditions will naturally be low therefore the implementation of the drought order is not expected to lead to any material additional landscape and visual amenity impacts	**Negligible**
Recreation	• Any reduction in wetted width and depth may influence water-dependent activities such as angling and canoeing. • However, water levels will already be naturally low in times of drought and will already have curtailed these recreational activities prior to the drought order implementation. • Any impacts will be temporary in nature and will be ameliorated once the drought has passed.	**Negligible**
Archaeology	• None of the scheduled ancient monuments identified in the features assessment have been identified as water dependent and water levels will already be naturally low in times of drought. • Any impacts will be temporary in nature and will be ameliorated once the drought has passed.	**Negligible**

6 LLYN BODLYN DROUGHT ORDER – MITIGATION

The environmental assessment has identified some significant impacts, including major hydrological impacts, major to moderate aquatic ecology impacts including on fish, macroinvertebrates, macrophytes, as well as minor impacts for phytobenthos.

For those receptors with a potential impact or risk identified as being significant as a result of implementation of the drought order, precautionary monitoring and mitigation measures have been identified, and will be further developed in consultation with NRW.

Mitigation measures are feature, location, species and community specific, and are targeted only to those impacts that arise specifically as a result of drought order implementation (as opposed to those arising due to environmental drought pressures). Similarly, monitoring and the targeting of mitigation measures to impacts that arise specifically as a result of drought order implementation will help identify the responsible party for the specific actions relating to the associated measure. Information attained through monitoring undertaken during future droughts and potential drought order implementation events will provide a tool for discussions regarding best working practices between Welsh Water, NRW and any other interested parties.

The range of mitigation measures that are possible for the features identified fall into three general activity types:

1) measures to reduce impacts at source

2) measures to modify environmental conditions in the river/lake

3) management of sensitive ecological species and communities.

The first activity type looks at mitigation measures that will reduce the pressure at source by reducing the hydrological impact. In the circumstances, the options are limited because the drought order is required to safeguard both water supply. The second activity focuses on mitigation measures that involve undertaking actions within the waterbodies to reduce the pressure at sensitive locations. The third activity type involves direct action to manage impact by movement or management of the receptor / feature itself.

The mitigation measures that could be considered at the on-set of drought, during implementation of the drought order and post-drought order implementation include:

6.1 Potential Generic Mitigation Measures Considered to Address Adverse Effects of the Drought Order

Type of Mitigation	Typical Application
Temporary reduction or cessation of the terms of the Drought Order/Permit	Where continuous water quality monitoring (typically dissolved oxygen) and/or fish distress monitoring indicate a sharp deterioration in aquatic conditions, modifications to abstraction licence conditions under the terms of the order/permit may need to be reduced or cease altogether until conditions have improved. The precise trigger levels for considering such action would be set out in discussion with NRW at the time of application taking account of the time of year and prevailing environmental conditions. Temporary cessation of the implementation of the order/permit may be required as a means of mitigating ecological effect, balanced against the need to safeguard public water supplies.
Fish distress monitoring with triggers and response plan	Regular visual observations carried out on key stretches of rivers or lakes to detect signs of large scale fish distress and agree appropriate mitigation with NRW specific to the conditions identified. This might include temporary oxygenation measures.
Protection of 'spate flows'	Temporary increases in river flows following periods of rain can be important to flush sediment/pollutants from the system or promote fish passage. Where possible, the terms of the drought order/permit could be temporarily reduced/suspended so that these spate flows are preferentially allowed to pass through the system. This decision would need to be taken in dialogue with NRW to take account of the prevailing conditions and considering the merits of encouraging fish migration during a drought.
Reduce fish predation	Consider (where feasible) a limited and targeted reduction of predation risk on fish through either the provision of refugia, in the form of artificial or natural habitat provision or improvement, or the placement of piscivorous bird scarers (in areas remote from residential locations). The merits of each option and subsequent deployment would be subject to review on a case-by-case basis in consultation with NRW.
Physical works	In some cases, temporary physical in-river works such as channel narrowing or provision of refugia could be carried out to mitigate environmental risks. If any physical works are likely to impact fish passage, appropriate mitigation measures will need to be considered as part of the design of the works.
Compensation flows	In some cases, it may be possible to use other sources of water to provide compensation flows within surface water courses to temporarily mitigate the impact of the drought order/permit
Provision of alternative water supplies	If there is a risk of derogation of other abstractors from the drought order/permit, it may be possible for Welsh Water to provide alternative water supplies or lower pumps in boreholes. Provision is otherwise provided in legislation[12] for compensation to be agreed with the abstractor.

A suggested suite of mitigation measures for environmental features with potentially significant impacts relating to implementation of the Llyn Bodlyn drought order are given in **Table 10.1**. For these features, a range of precautionary monitoring and triggers leading to enabling of appropriate mitigation measures are also described.

[12] Schedule 9 of the Water Resources Act (WRA) 1991

7 CUMULATIVE IMPACTS

In accordance with the DPG and the Habitats Regulations, consideration has been given to how the proposed drought order may affect the environment in combination with the effects of existing abstraction licences, environmental permits and other plans. This includes assessment of the potential cumulative effects of the following:

- Welsh Water's existing abstraction licences that operate within the hydrological zone of influence of the drought option, as well as other abstraction licences and discharge permits, as identified in NRW Review of Consents reports
- Assessment of cumulative impacts of the drought order with other Welsh Water supply-side and drought order / permit options within the hydrological zone of influence (including both intra- and inter- zone options)
- Other plans and projects of relevance, including
    - Any Welsh Water WRMP schemes which are scheduled to be implemented and become operational within the time period of the Drought Plan (i.e. before 2025)
    - Drought supply-side and drought order / permit options from other neighbouring water company Drought Plans and NRW Drought Plans
    - National Policy Statements for Wastewater and Renewable Energy Infrastructure
- Environmental monitoring before, during and after drought order implementation (see Section 10).

If a drought order application is progressed in the future, the potential for cumulative effects will be reviewed and revised to reflect any changes which are relevant to the timing of the drought order specified in the application.

Welsh Water's existing abstraction licences and other abstraction licences and discharge permits

The assessment of hydrological impacts presented in Appendix B, and summarised in Section 4, has considered how the proposed drought order may affect the environment in combination with the effects of existing licences and consents. Therefore, no relevant licences or consents have been identified as relevant for assessment of cumulative effects.

Other relevant Welsh Water drought permit / orders

No cumulative effects of implementing the Llyn Bodlyn drought order with any other drought order / permit schemes have been identified. However, this should be reviewed at the time of any future application for a drought order at Llyn Bodlyn

Reservoir.

Welsh Water WRMP schemes

No WRMP schemes identified with cumulative impacts.

NRW Drought Plans

No cumulative impacts of options in NRW Drought Plan with a drought order at Llyn Bodlyn are anticipated. However, this should be reviewed at time of future application for a drought order.

National Policy Statements for Wastewater and Renewable Energy Infrastructure

No cumulative schemes have been identified for assessment.

Environmental Monitoring

Recommendations for environmental monitoring before, during and after drought order implementation have been made in the EMP which is presented in Section 10 of this EAR. The EMP has been developed in consultation with NRW.

It is assumed that all monitoring activities will be undertaken with the best interests of the site in mind, and in discussion and agreement with NRW. Where activities which require in-river working are proposed, a method statement for the survey will be prepared and agreed with NRW in advance of the survey.

Assuming rigorous implementation of the method statements, there will be no adverse impacts of the monitoring on hydrology, water quality or ecology, and no adverse impacts of environmental monitoring on the site are anticipated.

8 LLYN BODLYN DROUGHT ORDER - SUMMARY OF RESIDUAL IMPACTS

The residual impact on environmental features is dependent on the effects observed during environmental monitoring, and the mitigation measures that are taken forward and their timely and effective application once the trigger for their need has been identified. Consequently, at this stage it is not possible to provide an accurate indication as to the residual impacts on environmental features due to implementation of mitigation measures. However, should the mitigation measures be effectively applied in all situations in a timely manner, it is anticipated that the magnitude of impacts, and in some cases the significance of impacts, will be reduced from those summarised in **Table 5.3**.

Should the application of mitigation measures applicable during the drought order implementation period not reduce the impact magnitude or significance, compensatory measures such as restocking will be considered to help ensure pre-drought conditions return and reduce the significance of any post-drought order impacts.

9 HABITATS REGULATIONS ASSESSMENT: STAGE 1 SCREENING

9.1 INTRODUCTION

Under Regulation 63 of the Habitats Regulations, the competent authority (in the case of a drought order in Wales this would be Welsh Ministers, advised by NRW) is required to undertake an Appropriate Assessment of any plan / project which is likely to have a significant effect on a European site, to determine the implications for the site in view of the site's conservation objectives. The Regulations state that a person applying for any such consent (in this case Welsh Water), must provide such information as the competent authority (Welsh Ministers, advised by NRW) may reasonably require for the purposes of the assessment or to enable them to determine whether an appropriate assessment is required.

9.1.1 HRA Stages

Stage 1 – Screening

The first stage in the Habitats Regulations Assessment (HRA) is screening to determine the potential of the drought order having any likely significant effect (LSE) on any European site (either alone or in-combination with other plans and projects) and thus if a full Stage 2 'Appropriate Assessment' of the drought order would be required.

An in-combination assessment is carried out to establish the possibility of cumulative or synergistic impacts.

The screening stage identifies if the drought order is likely to have significant effects on European designated site, and requires Appropriate Assessment.

Stage 2 – Appropriate Assessment

Drought orders that are identified during HRA Screening (Stage 1) as having LSE (either alone or in combination) will be taken forward to Appropriate Assessment. The Appropriate Assessment will consider the impacts of the drought order, against the conservation objectives of a European Site, in order to identify whether there are likely to be any adverse effects on site integrity and site features. The assessment will conclude whether or not the drought order, either alone or in combination with other plans and projects, would adversely affect the integrity of the European site in question. This is judged in terms of the implications of the plan for a site's conservation objectives, which relate to its 'qualifying features' (i.e. those Annex I habitats, Annex II species, and Annex I bird populations for which it has been designated). The responsibility for undertaking the Appropriate Assessment lies with the (Welsh

Ministers, advised by NRW).

Stage 3 – Alternative Options Stage

Where significant adverse effects are identified at the Appropriate Assessment stage, alternative options would be examined to avoid any potential damaging effects to the integrity of the European site.

Stage 4 – Assessment where adverse impacts remain

Stage 4 comprises an assessment of compensatory measures where, in the light of an assessment of Imperative Reasons of Overriding Public Interest, it is deemed that the project or plan should proceed. Imperative Reasons of Overriding Public Interest will only be progressed if no alternatives are identified as part of Stage 3.

9.2 STAGE 1 SCREENING OF LLYN BODLYN DROUGHT ORDER

The objective of this section is to bring together all relevant information to enable a screening exercise to be undertaken of the impacts of the Llyn Bodlyn drought order on relevant European designated sites.

These assessments have been completed in accordance with the DPG (see Section 3.3).

This section considers each of the Coedydd Derw a Safleoedd Ystlumod Meirion/Meirionnydd Oakwoods and Bat Sites SAC designated features and discusses the potential for the drought order to influence their status. For species, impacts on populations, range and supporting habitats and species have been considered.

9.2.1 Potential Impacts on SAC Designated Features

In carrying out the screening process, the assessment has considered the main possible sources of effects on the sites arising from the potential drought order, possible pathways to the designated sites and the effects on possible sensitive receptors in the sites. Only if there is an identifiable pathway between the impacted reaches and the designated sites, or individual receptors, is there likely to be an impact and where this is absent those sites have been screened out.

The screening assessment has also considered the Coedydd Derw a Safleoedd Ystlumod Meirion/Meirionnydd Oakwoods and Bat Sites SAC conservation objectives. The development of conservation objectives is required by the 1992 'Habitats' Directive (92/43/EEC). In accordance with the Habitats Directive, the objectives aim to achieve the 'favourable conservation status' of habitats and species features for which SAC is designated (see **Figure 9.1**).

Site-specific conservation objectives provide a description of what is considered to be the favourable conservation status of the feature within the whole plan area.

Conservation objectives for the site have been prepared by NRW.

Figure 9.1 Favourable conservation status as defined in Articles 1(e) and 1(i) of the Habitats Directive

"The conservation status of a natural habitat is the sum of the influences acting on it and its typical species that may affect its long-term natural distribution, structure and functions as well as the long term survival of its typical species. The conservation status of a natural habitat will be taken as favourable when:

- *Its natural range and areas it covers within that range are stable or increasing, and*
- *The specific structure and functions which are necessary for its long-term maintenance exist and are likely to continue to exist for the foreseeable future, and*
- *The conservation status of its typical species is favourable.*

The conservation status of a species is the sum of the influences acting on the species that may affect the long-term distribution and abundance of its populations. The conservation status will be taken as 'favourable' when:

- *Population dynamics data on the species indicate that it is maintaining itself on a long-term basis as a viable component of its natural habitats, and*
- *The natural range of the species is neither being reduced nor is likely to be reduced for the foreseeable future, and*
- *There is, and will probably continue to be, a sufficiently large habitat to maintain its populations on a long-term basis."*

In addition to the conservation objectives, the Core Management Plan has been used to determine LSEs against each of the specific attributes and targets for each of the qualifying features. A summary of the overall screening conclusion for each feature is provided below, with **Table 9.1** providing the assessment against each attribute and target.

Woodlands

This habitat type is not on the whole hydrologically dependant, not relying on a specific flow level in the river, and therefore many elements are unlikely to be adversely affected by the drought order. However, sensitive assemblages of "Atlantic" species, which occur in the mist and splash zones of rivers, waterfalls and cascades, is a defining feature of this habitat type and the drought order therefore has potential to affect the SAC.

Hydrological impacts on Afon Ysgethin within the SAC and SSSI (Reach 2) are expected to be moderate with a reduction in summer low (Q_{95}) and extreme low flows (Q_{99}) of 16.7% of and 20.4% respectively. Resultant changes in wetted width, splash and humidity have the potential to effect elements of the bryophyte and lichen

community, although such effects are expected to be limited due to the already limited nature of splash and humidity occurring at low flows during drought. A reduction in compensation flow in the river as a result of the implementation of the drought order is unlikely to have any *short-term* impact on the majority of the humidity-sensitive bryophytes as ambient humidity will be buffered to a certain extent by the woodland canopy over the river.

More vulnerable are those species whose natural habitat is close to the normal water level and which depend on periodic cycles of inundation and exposure. Lowering of water levels is likely to expose *Platyhypnidium lusitanicum* and *Porella pinnata* for longer periods and this may cause colonies to shrink or retreat downwards. A lower compensation flow may also have similar impacts on the population of *H. wulfsbergii*, which also requires regular wetting via occasional submergence and splashing .As flows during a drought period would normally be low and therefore splash and humidity already naturally limited, the degree to which sensitive species such as Atlantic bryophytes are likely to be affected by the hydrological changes would be expected to be less than if mid-range flows were affected (as for e.g. abstraction for hydroelectric schemes).

Given the limited duration of the drought order it is expected that any effects on the bryophyte community would be reversed following return to the normal hydrological regime.

As a result, it can be concluded that implementation of a drought order has the potential to result in likely significant effects on the woodland habitats within the Coedydd Derw a Safleoedd Ystlumod Meirion / Meirionnydd Oakwoods and Bat Sites SAC.

Lesser Horseshoe Bats

The drought order would have negligible impact on this SAC designated feature as this feature does not rely on a specific flow level in the river.

As a result, it can be concluded that implementation of a drought order would not result in any likely significant effects on this species within the Coedydd Derw a Safleoedd Ystlumod Meirion / Meirionnydd Oakwoods and Bat Sites SAC and is therefore screened out of this assessment.

European Dry Heaths The drought order would have negligible impact on this designated feature as this SAC feature is not hydrologically connected to the river (in terms of the river feeding the heath) and the condition of the habitat does not rely on a specific flow level in the river.

As a result, it can be concluded that implementation of a drought order would not result in any likely significant effects on European dry heaths within the Coedydd Derw

a Safleoedd Ystlumod Meirion / Meirionnydd Oakwoods and Bat Sites SAC and is therefore screened out of this assessment with no likely significant effects.

Watercourses of Plain to Montane Levels with the Ranunculion fluitantis and Callitricho-Batrachion Vegetation

This habitat type is only found in Unit 27 (Afon Glaslyn) of the SAC. This is approximately 10 miles north of the Afon Ysgethin and there is no hydrological connection between the two rivers.

As a result, it can be concluded that implementation of a drought order would not result in any likely significant effects on this habitat within the Coedydd Derw a Safleoedd Ystlumod Meirion / Meirionnydd Oakwoods and Bat Sites SAC and is therefore screened out of this assessment with no likely significant effects.

Table 9.1 Summary of Likely Significant Effects of Llyn Bodlyn Drought Order Implementation Against Conservation Objectives for the Coedydd Derw a Safleoedd Ystlumod Meirion / Meirionnydd Oakwoods and Bat Sites SAC

Feature	Attribute (from NRW)	Site Specific Target range and Measures	Potential Impact of drought order and level of certainty	Potential impact on achievement of objective
Coedydd Derw a Safleoedd Ystlumod Meirion / Meirionnydd Oakwoods and Bat Sites SAC				
Woodlands	Humidity	High humidity must be maintained	Potential adverse effects of drought order implementation on humidity.	Yes

9.2.2 Summary

In summary, likely significant effects have been identified for the designated features of the Coedydd Derw a Safleoedd Ystlumod Meirion / Meirionnydd Oakwoods and Bat Sites SAC.

A Stage 2 Appropriate Assessment has therefore been carried out to identify whether the implementation of the drought order will result in adverse effects on the site's conservation objectives and therefore whether the overall site integrity would be compromised. This is reported separately.

9.2.3 Cumulative and In-combination Impacts

The Habitats Directive requires a consideration in the assessment of '*any plan or project not directly connected with or necessary to the management of the site but likely to have a significant effect thereon, either individually or in combination with other plan or projects*'.

Consideration of potential plans or projects with cumulative effects is presented in Section 7.

10 ENVIRONMENTAL MONITORING PLAN (EMP)

10.1 INTRODUCTION

The overall scope of the EMP for the Llyn Bodlyn drought order meets the requirements of Section 5.2 (Monitoring) and informs the requirements of Section 5.3 (Mitigation) of DPG. As required by the DPG, the level of monitoring identified in the EMP is risk-based. The EMP is tailored to the characteristics of the study area and is informed by the knowledge and assessment of environmental sensitivity (presented in Sections 4 and 5 of this EAR). The EMP fulfils several requirements, including:

- Establishing required baseline environmental monitoring and data acquisition to maintain and update the understanding of the environmental baseline conditions and to reduce uncertainties in the assessment.
- Pre-drought order monitoring describes the prevailing environmental conditions prior to drought order implementation. This will inform the implementation and management of any mitigation actions during the drought.
- During-drought order monitoring describes the environmental conditions during the implementation of the drought order. Surveillance monitoring of sensitive locations, informed by, for example, walkover surveys and pre-drought monitoring, will provide early warnings of any unpredicted environmental impacts and ensure that mitigation actions are operating as designed.
- Post-drought order monitoring describes the recovery of environmental conditions following the cessation of a drought order, and establishes whether the affected ecosystems have recovered to conditions prevailing in the pre-drought order period.

The basis of the development of the EMP is provided in Section 10.2. Monitoring recommendations are set out in Section 10.3.

10.2 BASIS OF THE EMP

Guidance on the objectives and content of the EMP is given in Section 5.2 and Appendix J of the DPG.

The guidance states that:

- Water companies are responsible for understanding the effects of a drought and its drought management actions on the environment and that companies can demonstrate this by assessing the impacts of drought management actions during and after a drought and completing the environment assessment.
- Companies should ensure that adequate arrangements for environmental monitoring are detailed in an EMP within its drought plan.

- The level of monitoring needed should be risk-based. Not all sites will require in-drought and post-drought monitoring.
- Surveys may be needed to support/inform the decisions on environmental sensitivity and likely impact or to ascertain baseline conditions.
- In-drought order monitoring is required to assess the impacts from the implementation of the drought management action and for the management of mitigation actions during a drought.
- Post-drought order monitoring aims to assess a site's recovery.
- Sites with moderate to major environmental risk should focus monitoring on those feature(s) sensitive to the likely impacts from implementing drought management actions. For Habitats Directive sites, data collected will be sufficient to demonstrate there is no adverse effect on the interest features. For SSSIs, data collected will need to be sensitive enough to pick up the likelihood of damage at the site. For WFD sites data collected will be to assess any potential 'deterioration' to status and allow you to comply with the requirements of Articles 4.6 to 4.9.
- Control sites are important to provide a comparison between the 'natural' impacts of the drought and the impacts of the drought management action.
- The EMP should include details of any surveys to support the environmental assessment, in-drought and post-drought data needs, including:
    - the feature/s to be monitored and the methods used
    - the location of survey sites
    - the timing and frequency of monitoring
    - who will undertake the monitoring.
- Separating the 'natural' impacts of a drought from those resulting from the implementation of drought management actions can be complex and made more difficult where data problems and/or a lack of hydro-ecological understanding exists. Water companies must ensure that their EMP is adequate to assess the most significant environmental impacts of its proposed drought actions and associated mitigation measures.
- The EMP needs to be agreed with NRW. Consultation with NRW should be undertaken to ensure that the monitoring proposed within the EMP to assess the potential impacts at these sites is adequate.
- A water company must provide details in the Drought Plan of likely mitigation or compensation needed against serious impacts on the environment or other water users of any proposed drought action. The EMP should assist in identifying sites that may require mitigation. In some cases, mitigation actions may be necessary to prevent derogation of other abstractions (for example, by providing alternative supplies or releasing compensation water into watercourses to limit the impact of

reduced flows).

10.3 MONITORING RECOMMENDATIONS

The EMP describes the nature and extent of the baseline and drought year data that would be required in order to differentiate the impacts resulting solely from the implementation of a drought order with those resulting naturally as a result of the drought itself. The EMP is site specific and the scope is based on the current assessment of the drought order.

Recommendations for pre-drought, in drought and post-drought monitoring, based on the outcome of the current environmental assessment, are provided in **Table 10.1.** and are illustrated on **Figure 10.1**.

Monitoring outside of drought conditions is also recommended to address the baseline data limitations to the environmental assessment identified in this report and ensure a robust baseline exists for all sensitive features.

Data and results from baseline monitoring will increase the robustness of the assessment, and will be incorporated at the time of EAR preparation to support any future application for drought powers. The impact assessment has adopted a precautionary approach where baseline data limitations have been identified.

Control sites are crucial in assessing the ecological impact of flow pressure resulting from water resource activities. They can help determine whether any ecological impact being observed is a result of the water resource activity being investigated, rather than wider environmental influences. Good control sites for hydroecological assessment should be chosen where there are no significant water quality problems or pressures which could undermine relationships between ecology and flow. They must not be affected by the water resource activity being investigated nor have additional water resource activity upstream that could affect the flow regime. It is imperative that they are as similar in nature to the baseline conditions of the impact sites as possible, most importantly stream size and channel gradient. Possible options could include reaches upstream of those impacted, or other watercourses where the watercourses are comparable and not subject to a drought permit/order application. Control sites will need to be identified at the time of application following a review of where drought permit/orders are required to be implemented. Consultation with NRW to determine suitable control sites will be undertaken at the time of application of this drought order.

The following monitoring programme is an initial draft and will be iterated and agreed with NRW prior to EMP implementation. Any updates to the EMP will consider:

- Any potential changes in the assessment of the hydrological, water quality and geomorphological impacts based on baseline conditions at the onset of drought;

- Any potential changes in the assessment of impacts on environmental features based on baseline conditions at the onset of drought; and
- Any changes in assessment and/or monitoring methodologies and biological indices.

Table 10.1 Baseline, Pre, Onset, During and Post Drought Order Monitoring and Mitigation Recommendations

Feature and reach	Potential Impact identified in EAR	Pre-drought baseline monitoring	On-set of environmental drought	During Drought Order Implementation Period		Post Drought Order	Responsibility
		Key locations	**Monitoring and trigger setting**	**Trigger and monitoring to inform mitigation action**	**Mitigation actions triggered by monitoring**	**Monitoring and post-drought mitigation (where applicable)**	
N/A		Spot flow gauging surveys at: • Afon Ysgethin at Llyn Bodlyn reservoir outflow (SH64512378) • Afon Ysgethin at Pont Scethin (SH63452355) • Afon Ysgethin at Pont Fadog (SH60742257) • Afon Ysgethin at Tal-y-bont (A496 road crossing) (SH58982177)	Surveys at baseline site locations. Three occasions.	Surveys at baseline site locations. Three occasions.	N/A	Surveys at baseline site locations. Three occasions.	Welsh Water
		Biochemical water quality sampling.	One site per hydrological reach. Monthly. Consider continuous monitoring.	One site per hydrological reach. Weekly. Consider continuous monitoring.	N/A	One site per hydrological reach. Monthly, until recovery to pre-drought levels. Consider continuous monitoring.	Welsh Water
Macrophytes **Reaches 1 and 2**	• Reduction in abundance and distribution of flow sensitive taxa • Loss of marginal habitats and reduction in abundance and distribution of species utilising such habitats • Increase in filamentous algae levels due to increased nutrients or water	The macrophyte community in the impacted reaches is well understood as a result of monitoring carried out by Welsh Water, including in 2011[13], 2016-17[14] and 2018[15]. Surveys to ideally be carried out to provide a three-year baseline dataset, then repeated every three years. Follow LEAFPACS2 standard methodology. To be carried out annually during June-September. To complement any existing NRW monitoring, in discussion with NRW. Monitoring sites are located at:	Survey to be undertaken and macrophytes identified (if drought order likely to be implemented in plant growing season June-September). Follow LEAFPACS2 standard methodology[16]. Walkover survey to identify any key sources of nutrient loading. Carry out water quality sampling at the baseline sites including samples for soluble reactive phosphorus.	Walkover of key sections known to be susceptible to lower flows, informed by pre-drought survey. If drought order implementation occurs in June-September, carry out macrophyte surveys at baseline sites. Follow LEAFPACS2 standard methodology for assessing macrophyte communities. Carry out water quality sampling at the baseline	Mitigating impacts to the macrophyte community as a result of lowered flow and water level is not feasible during drought order implementation. Mitigating this impact should be triggered by post drought macrophyte community assessments to implement post drought mitigation measures. Consider measures to address identified point sources of nutrient	In the two years following drought order implementation and in June to September monitoring period carry out LEAFPACS2 macrophyte surveys at the baseline monitoring sites. To be extended if recovery has not occurred in two years. Significant alteration to macrophyte community composition (as informed by expert judgement, based on baseline data and multivariate statistical	Welsh Water

[13] AMEC (2012). Environmental Assessment of Llyn Bodlyn Reservoir Drought Order. A report for Dŵr Cymru Welsh Water. January 2012.
[14] Apem (2018) Dwr Cymru Welsh Water Drought Plan Monitoring 2016 to 2018: Llyn Bodlyn, July 2018
[15] Ricardo (2018) Llyn Bodlyn Drought Plan Environmental Monitoring Report 2018. Report prepared for Welsh Water.
[16] Environment Agency (2011). Surveying freshwater macrophytes in rivers. Operational instruction 131_07. (Unpublished procedures manual)

Feature and reach	Potential Impact identified in EAR	Pre-drought baseline monitoring Key locations	On-set of environmental drought Monitoring and trigger setting	During Drought Order Implementation Period Trigger and monitoring to inform mitigation action	 Mitigation actions triggered by monitoring	Post Drought Order Monitoring and post-drought mitigation (where applicable)	Responsibility
	temperature and decreased velocity	• Reach 1 N8-2/Site 3/LB1-1 • Reach 2 - N8-6/Site 9.		sites including samples for soluble reactive phosphorus.	loading. Consider scope for addressing any identified sources of nutrient loading from walkover survey, if this would help address water quality risks. Consider possible in-stream measures or adjustments to improve habitat conditions.	analyses) triggers post drought mitigation actions: If existing macrophyte community has significantly deteriorated, consider reseeding /replanting where possible to promote recovery. Replanting of macrophyte community composition to be informed by pre-drought community. Consider the removal of fine silt by manual raking of small areas to improve habitat quality.	
Macroinvertebrates **Reaches 1 and 2**	• Reduction in species diversity as a result of the loss of flow-sensitive taxa • Loss of marginal habitats and reduction in abundance and distribution of species utilising such habitats • Alteration to community composition as a result of water quality deterioration.	The macroinvertebrate community in the impacted reaches is well understood as a result of monitoring carried out by Welsh Water Welsh Water, including in 2011[17], 2016-17[18] and 2018[19]. Surveys to ideally be carried out to provide a three-year baseline dataset, then repeated every three years. Two sites per impacted reach. To complement any existing NRW monitoring, in discussion with NRW. Monitoring sites are located at:	Seasonal monitoring of macroinvertebrates at the baseline survey sites (spring and autumn). Samples to be collected and identified to species level. Carry out water quality surveys at same time. In severe drought conditions, no in stream monitoring is advised during environmental drought to prevent further harm to the invertebrate community through kick/ sweep sampling.	Seasonal monitoring of macroinvertebrates at the baseline survey sites (spring and autumn). Samples to be collected and identified to species level. Carry out water quality surveys at same time. In severe drought conditions, no in stream monitoring is advised during environmental drought to prevent further harm to the invertebrate community	Mitigating impacts to the macroinvertebrate community as a result of lowered flow and water level is not feasible during drought order implementation. Mitigating this impact should be triggered by post drought macroinvertebrate community assessments to implement post drought mitigation measures.	In the two years following drought order implementation, 3-minute kick sampling and mixed taxon level analysis at the five routine monitoring sites. To be extended if recovery has not occurred in two years. Significant alteration to macroinvertebrate community composition (as informed by expert judgement and based on baseline data) triggers post drought mitigation actions:	Welsh Water

[17] AMEC (2012). Environmental Assessment of Llyn Bodlyn Reservoir Drought Order. A report for Dŵr Cymru Welsh Water. January 2012.
[18] Apem (2018) Dwr Cymru Welsh Water Drought Plan Monitoring 2016 to 2018: Llyn Bodlyn, July 2018
[19] Ricardo (2018) Llyn Bodlyn Drought Plan Environmental Monitoring Report 2018. Report prepared for Welsh Water.

Feature and reach	Potential Impact identified in EAR	Pre-drought baseline monitoring	On-set of environmental drought	During Drought Order Implementation Period		Post Drought Order	Responsibility
		Key locations	Monitoring and trigger setting	Trigger and monitoring to inform mitigation action	Mitigation actions triggered by monitoring	Monitoring and post-drought mitigation (where applicable)	
		• Reach 1: N8-1/Site 1/LB4 and N8-2/Site 3/LB3 • Reach 2: N84/Site 7/LB2 and N8-8/Site 11/LB2-2.		through kick/ sweep sampling.	Consider possible in-stream measures or adjustments to improve habitat conditions. Consider the removal of fine silt by manual raking of small areas.	• Targeted habitat alteration/improvements can enhance natural recovery. Habitat restoration techniques can be utilised to improve habitat quality, and flush sediment from benthic substrate. • Consider the removal of fine silt by manual raking of small areas.	
Fish (including salmon, brown trout, eel) **Reaches 1 and 2**	Decreased growth, alteration to feeding and migration Siltation of spawning gravels Loss of important habitats (spawning gravels, nursery habitat, resting pools) Increased mortality (density dependant) as a result of increased predation and competition Stranding of individuals as a	Fisheries surveys were undertaken on behalf of Welsh Water in 2017 in the impacted reaches in 2011[20], 2012[21], and 2016[22]. Limited older data is also available from NRW. Surveys to be repeated every three years. To complement any existing NRW monitoring, in discussion with NRW. Monitoring sites are located at: • Reach 1 – Y1, Y2, Y3 and Y4 • Reach 2 - Y5, Y6, Y7, Y8.	Electric-fishing surveys to monitor fish populations at one site in each of the impacted reaches. One site in each of the impacted reaches. In severe drought conditions, no fish population surveys are advised during drought as this may cause further stress. Walkover of key sections known to be susceptible to lower flows: • Identification of key habitats which are at risk of fragmentation. • Identification of key structures which may provide a barrier at lower flows.	No fish population surveys are advised during drought as this may cause further stress. Additional walkovers, if situation is expected to deteriorate in stream sections known to contain to contain high fish densities, spawning, nursery and cover habitats. Record extent of exposed marginal habitats, spawning habitats, bed substrates and estimates of overlaying silt cover. Frequency of walkovers to be determined based	Targeted installation of woody debris features to provide fish with the habitat required to support feeding and development (growth). If the results of the walkovers deem spawning gravels to be at risk to siltation, the following mitigation action/s may be undertaken: • Gravel washing of key spawning areas to be undertaken prior to salmonid spawning period (winter)[23]	Two years of annual post-drought fish population surveys at baseline monitoring sites (corresponding with a control and impact site/s) to determine any changes in population dynamics both temporally and spatially. The results of the fish population surveys should help inform mitigation targeting habitat restoration where deemed to be appropriate to support and enhance affected populations. Walkover of key spawning	Welsh Water

[20] AMEC (2012). Environmental Assessment of Llyn Bodlyn Reservoir Drought Order. A report for Dŵr Cymru Welsh Water. January 2012.
[21] Cascade (2013). Environmental Monitoring Studies for the Llyn Bodlyn Reservoir (N8) Drought Order. A report for Dŵr Cymru Welsh Water. January 2013.
[22] Apem (2018) Dwr Cymru Welsh Water Drought Plan Monitoring 2016 to 2018: Llyn Bodlyn, July 2018
[23] Wild Trout Trust Habitat Management Sheet – Gravel Cleaning http://www.wildtrout.org/sites/default/files/library/Gravel_Cleaning_Apr2012_WEB.pdf

Feature and reach	Potential Impact identified in EAR	Pre-drought baseline monitoring Key locations	On-set of environmental drought Monitoring and trigger setting	During Drought Order Implementation Period Trigger and monitoring to inform mitigation action	 Mitigation actions triggered by monitoring	Post Drought Order Monitoring and post-drought mitigation (where applicable)	Responsibility
	result of a reduction in velocity Fragmentation of habitats and increased significance of obstacles/barriers Changes in flows and water levels may delay or prevent passage over barriers to migration Mortality as a result of water quality deterioration (oxygen stress, gill clogging) Alteration to species distribution and abundance as a result of water quality deterioration.		• Identification of key spawning locations recording the number of redds potentially affected, undertaken during the salmonid winter spawning period (depending on order being implemented during the salmonid winter spawning period). Record extent of exposed marginal habitats, spawning habitats, composition of the bed substrate and estimates of overlaying silt cover. Approximation of the number of each fish species (e.g. 10s, 100s) in each ponded reach, where safe and practical to do so. Measure dissolved oxygen, conductivity and temperature in the field using calibrated handheld equipment. Appropriate trigger values would be set for level and flow for spawning habitats based on local circumstances, timing, seasonality and expert opinion.	on the on-set of environmental drought walkover and expert judgement of the resolution required to monitor the impacts of the drought. Targeted fish passage assessment of barriers /obstructions to fish passage and any associated fish passes should be undertaken to ascertain if they pose an increased risk to the free movement of fish during key migration periods. Frequency of fish passage assessments to be determined based on the on-set of environmental drought walkover and expert judgement of the resolution required to monitor the impacts of the drought. Measure dissolved oxygen, conductivity and temperature in the field using calibrated handheld equipment. Deployment of automated water quality	• Targeted installation of woody debris features to increase localised flow velocity/scour at impacted spawning gravels (to aid sediment transport and increase water depth for spawning depth) If the results of the walkovers deem important habitats to be at risk to exposure/ reduction (in extent), the following mitigation action/s may be undertaken: • Targeted installation of woody debris features to increase flow heterogeneity/scour and marginal cover in shallow areas of the channel[24] • Deployment of aeration equipment in key reaches that have standing or slow flowing water with low oxygen levels. • Targeted installation of woody	locations recording the number of redds potentially affected, undertaken during the winter spawning period. Record extent of exposed marginal habitats, spawning habitats, composition of the bed substrate and estimates of overlaying silt cover. If the results of the walkovers deem spawning gravels to have suffered from siltation, the following mitigation action/s may be undertaken: Gravel washing of key spawning areas to be undertaken prior to salmonid spawning period (winter)[25] Targeted installation of woody debris features to: • increase flow heterogeneity/scour and marginal cover in shallow areas of the channel[26] • increase localised flow velocity/scour at impacted spawning gravels (to aide sediment transport and increase water depth for spawning	

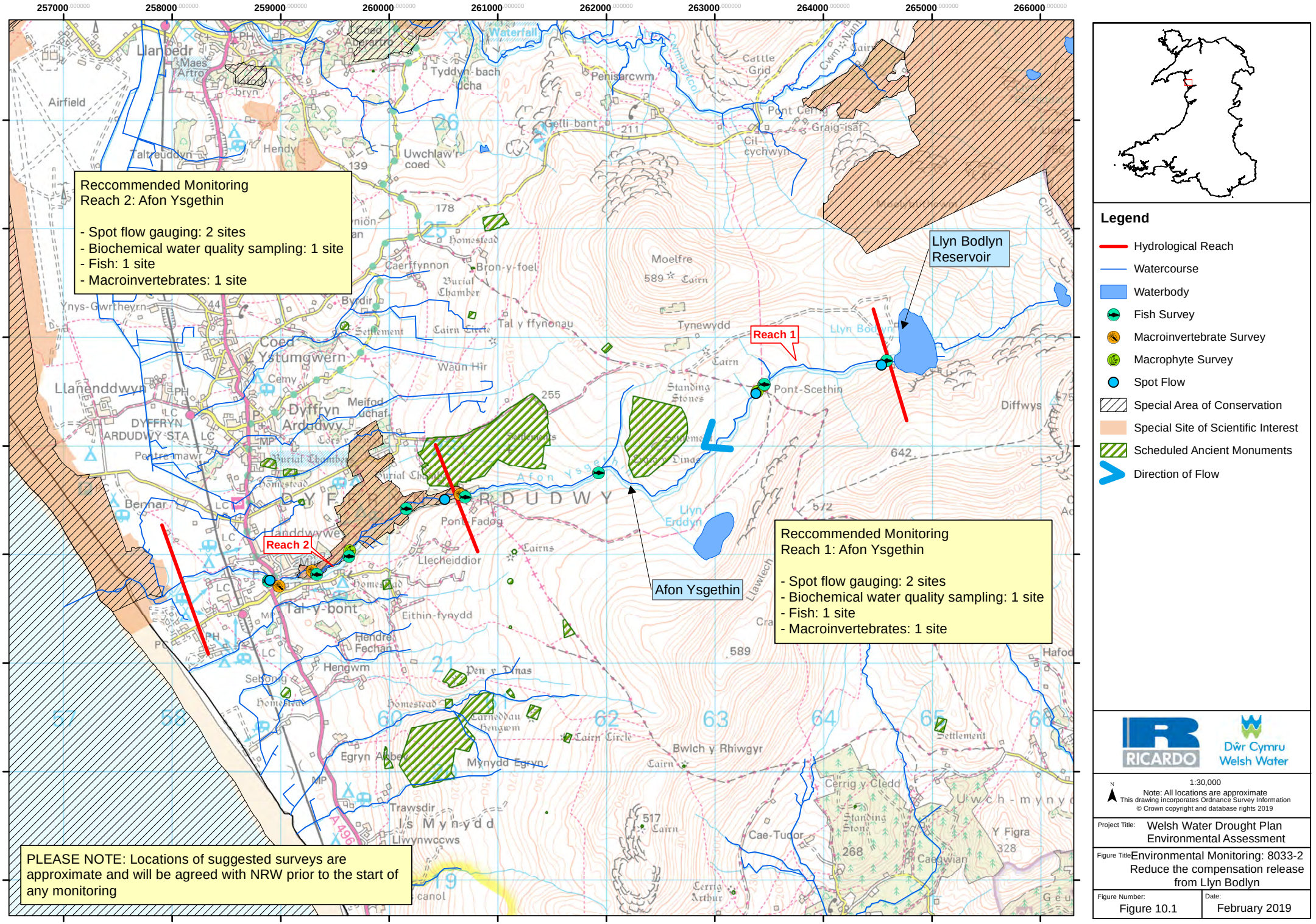
[24] Wild Trout Trust Chalkstream Habitat Manual – Use of Large Woody Debris http://www.wildtrout.org/sites/default/files/library/Large_Woody_Debris.pdf
[25] Wild Trout Trust Habitat Management Sheet – Gravel Cleaning http://www.wildtrout.org/sites/default/files/library/Gravel_Cleaning_Apr2012_WEB.pdf
[26] Wild Trout Trust Chalkstream Habitat Manual – Use of Large Woody Debris http://www.wildtrout.org/sites/default/files/library/Large_Woody_Debris.pdf

Feature and reach	Potential Impact identified in EAR	Pre-drought baseline monitoring	On-set of environmental drought	During Drought Order Implementation Period		Post Drought Order	Responsibility
		Key locations	Monitoring and trigger setting	Trigger and monitoring to inform mitigation action	Mitigation actions triggered by monitoring	Monitoring and post-drought mitigation (where applicable)	
				equipment that continuously monitors for dissolved oxygen.	debris features to provide submerged and overhead cover from predation where significant abundances of fish have been identified by walkover surveys. Consider provision of physical deterrents to deter piscivorous birds at significant locations (e.g. scare crows) in consultation with NRW. In extreme cases (where environmental parameters such as dissolved oxygen and temperature allow), consider removal of concentrated abundances of fish deemed to be stranded/at risk, relocating fish to suitable locations outside of the impacted reach within more suitable catchment, but would need to be discussed with NRW to ensure compliance with the Keeping and Introduction of Fish Regulations 2014. Modify any impacted fish passes (where possible) to ensure passage is maintained during key migration	depth) If the results of the walkovers deem important habitats to be at risk to exposure/ reduction (in extent), the following mitigation action/s may be undertaken: • Targeted fish passage assessment of barriers /obstructions to fish passage and any associated fish passes should be undertaken to ascertain if they pose an increased risk to the free movement of fish during key migration periods, i.e. during juvenile eel migration (spring/summer). • Modify any impacted fish passes (where possible) to ensure passage is achievable during key migration periods (e.g. agree to provide an appropriate proportion of flow into the pass to enable passage). Where fish passage is not currently provided at a barrier, investigate appropriate methods of improving passage (e.g. fish passage design and installation).	

Feature and reach	Potential Impact identified in EAR	Pre-drought baseline monitoring	On-set of environmental drought	During Drought Order Implementation Period		Post Drought Order	Responsibility
		Key locations	Monitoring and trigger setting	Trigger and monitoring to inform mitigation action	Mitigation actions triggered by monitoring	Monitoring and post-drought mitigation (where applicable)	
					periods (e.g. agree to provide an appropriate proportion of flow into the pass to enable passage). Consider 'Trap & Transport' of concentrated abundances of migrating fish accumulated below impassable barrier/s to spawning grounds upstream of the impacted reach (where environmental parameters such as dissolved oxygen and temperature allow). Alternatively, mitigation should seek to protect any populations 'trapped' as a result of the barrier/s until flows increase for example by using aeration (if dissolved oxygen levels are low) or preventing predation (see Increased Mortality impact mitigation actions outlined above). Deployment of aeration equipment in key reaches that have standing or slow flowing water with low oxygen levels.		
Meirionnydd Oakwoods and Bat Sites SAC / Coed	Potential impacts on bryophytes in Reach 2 related to	Welsh Water commissioned a	Repeat survey following 2018 methodology.	Repeat survey following 2018 methodology.	No additional measures specified.	Repeat survey following 2018 methodology.	Welsh Water

Feature and reach	Potential Impact identified in EAR	Pre-drought baseline monitoring Key locations	On-set of environmental drought Monitoring and trigger setting	During Drought Order Implementation Period Trigger and monitoring to inform mitigation action	 Mitigation actions triggered by monitoring	Post Drought Order Monitoring and post-drought mitigation (where applicable)	Responsibility
Corsy Gredol SSSI	reduction in humidity.	bryophyte survey in 2018[27]. Baseline data were collected through 20cm x 20cm quadrat sampling in three riparian zones within Coed Gors y Gedol SSSI (lower stream channel, low to high water, and above high water), and percentage cover of each species of bryophyte (mosses, liverworts and hornwarts) present was recorded.					
Phytobenthos	Decrease in flow affecting phytobenthos community composition. Increases in nutrient level, increases in water temperature. Increases in filamentous algae smothering the substrate.	The phytobenthos community in the impacted reaches is well understood as a result of monitoring carried out by Welsh Water, including in 2018[28]. Surveys to ideally be carried out to provide a three-year baseline dataset, then repeated every three years. Follow DARLEQ2 protocol. To be carried out annually during June-September. To complement any existing NRW monitoring, in discussion with NRW. Monitoring sites are located at: • Reach 1 – Site 2 and Site 3 • Reach 2 - Site 8 and Site 10.	Sampling according to DARLEQ2 protocol, two sites in each impacted reach, at least 1 year, ideally 2-year baseline, ideally encompassing 1 x "normal" flow year and 1x "dry" flow year, 2 x sampling per year, in spring and autumn.	Sampling according to DARLEQ2 protocol, at baseline survey sites, in spring and autumn.	No additional measures specified.	Sampling according to DARLEQ2 protocol, at baseline survey sites, in spring and autumn.	Welsh Water

[27] Ricardo (2018) Llyn Bodlyn Drought Plan Environmental Monitoring Report 2018. Report prepared for Welsh Water.
[28] Ricardo (2018) Llyn Bodlyn Drought Plan Environmental Monitoring Report 2018. Report prepared for Welsh Water.



Legend

- Hydrological Reach
- Watercourse
- Waterbody
- Fish Survey
- Macroinvertebrate Survey
- Macrophyte Survey
- Spot Flow
- Special Area of Conservation
- Special Site of Scientific Interest
- Scheduled Ancient Monuments
- Direction of Flow

RICARDO

Dŵr Cymru Welsh Water

1:30,000

Note: All locations are approximate

Project Title:	Welsh Water Drought Plan Environmental Assessment
Figure Title	Environmental Monitoring: 8033-2 Reduce the compensation release from Llyn Bodlyn
Figure Number:	Figure 10.1
Date:	February 2019

11 CONCLUSIONS

This EAR provides an assessment of the potential environmental impacts relating to the implementation of the Llyn Bodlyn drought order. The drought order involves a proposed reduction in the statutory compensation flow release from Llyn Bodlyn to the Afon Ysgethin from 2.18Ml/d to 1.18Ml/d. This would conserve the longevity of reservoir storage for use in direct supply during a drought. The drought order will potentially influence the downstream Afon Ysgethin.

The scope of the assessment has been defined by an impact screening and scoping exercise. In accordance with the DPG, the screening exercise involved two stages, a hydrological impact assessment (Stage 1) and the identification of the environmental features that could be affected by the drought order (Stage 2).

The hydrological impact assessment is identified as **major** impact on the Afon Ysgethin, due to the reduced reservoir compensation flow release. **Minor** impacts have been identified on the physical environment of the river as a consequence of the hydrological impact, including water quality.

An environmental assessment was therefore required and included for features where screening has identified a major or moderate impact. Screening identified Meirionnydd Oakwoods and Bat Sites / Coedydd Derw a Safleoedd Ystlumod Merion SAC and Coed Cors y Gredol SSSI, WFD Status and Community Assessment / Notable Species, and landscape, recreation and archaeology as environmental features for which an environmental assessment was required. The assessment has concluded that there are **major-moderate** impacts on aquatic ecology, specifically: major impacts on fish and moderate impacts on macroinvertebrates and macrophytes; and minor impacts on phytobenthos.

No cumulative effects with existing licences, consents and plans are currently anticipated. However, this position should be reviewed at the time of any future application for a drought order at Llyn Bodlyn.

The environmental assessment has identified significant impacts of implementation of a drought order at Llyn Bodlyn. Consequently, in line with the DPG for drought order assessments, mitigation measures have been proposed and further discussion with NRW is required in order to develop suitable mitigation measures.

In summary, it has been concluded that the environmental effects on river flows, water quality and ecology of implementing a drought order at Llyn Bodlyn, over and above those conditions that already exist under "normal", i.e. licensed, baseline conditions, with the onset of a natural drought, would be **major.**

APPENDIX A
HYDROLOGY AND HYDROGEOLOGY METHODOLOGY

A.1 HYDROLOGICAL AND HYDROGEOLOGY IMPACT METHODOLOGY (STAGE 1 SCREENING)

Consideration is required (by the DPG[1]) of the likely changes in flow / level regime due to implementing the drought management action, specifically:

- the perceived extent of potential impact
- the nature and duration of the potential impact
- the timing of the potential impact.

The hydrogeological and hydrological information is used together with information on the other environmental features in the study area from Stage 2 - Environmental Sensitivity (see Section 3.2.1 in main report) to identify the environmental risk of the drought order / permit.

Although the DPG informs the hydrometric data to be used as part of environmental features for consideration within the environmental assessment (see Box 1 Appendix H of the DPG), it does not provide a methodology for identifying the hydrological impact.

Cascade has developed a flexible approach[2] to identifying the spatial extent of the study area from hydrological information and characterising the hydrological impact within the study area, in terms of the scale, nature, duration and timing of impacts, although this is only appropriate to apply to reaches that do not dry naturally. A hydrological methodology for watercourses that naturally dry for part of the year is also presented that characterises the hydrological impact within the study area, in terms of the scale, nature, duration and timing of impacts. These are presented below.

Perennially flowing watercourse hydrological methodology

This methodology is applied to watercourses that flow throughout the year and that are potentially impacted on by the drought order / permit.

Core to this approach is the use of relevant long term flow statistics to inform the scale of hydrological impact and thereby delimit the zone of influence in the downstream river system. To determine these, potential reductions in flow resulting from implementation of the drought order / permit are compared with flows without the drought order / permit in place (i.e. the additional abstraction advocated by the drought order / permit over and above the existing abstraction). This helps to determine the scale of potential impact at any particular site/ feature using the matrix in **Figure A.1** or **Figure A.2** depending on the altitude of the waterbody and whether it is classified as lowland or upland[3]. Where possible, the hydrological assessments presented in previous EMPs and EARs of the drought options have been used to

1 Welsh Government / Defra / NRW / Environment Agency (2011). Water Company Drought Plan Guideline. June 2011.
2 Hydrological impact approach used in previous drought plan environmental assessments for water companies including Thames Water, Yorkshire Water and United Utilities
3 The River Basin Districts Typology, Standards and Groundwater threshold values (Water Framework Directive) (England and Wales) Directions 2010. ISBN 978-0-85521-192-9.
The Directions set out the principles of classification of surface water and groundwater bodies, including the use of 80m above Ordnance Datum as the altitude that differentiates water quality requirements for upland and lowland biology. Where there are ambiguities, or thresholds are crossed, upland is assumed to apply to ensure a precautionary assessment.

help identify the spatial extent of the study area from hydrological information and characterising the hydrological impact within the study area.

Figure A.1 Hydrological Assessment Matrix (Upland)

		Summer Q99		
	% reduction in flow	<10%	10-25%	>25%
Summer Q95	<10%	Negligible	Minor	Moderate
	10-25%	Minor	Moderate	Major
	>25%	Moderate	Major	Major

Figure A.2 Hydrological Assessment Matrix (Lowland)

		Summer Q99		
	% reduction in flow	<10%	10-25%	>25%
Summer Q95	<20%	Negligible	Minor	Moderate
	20-50%	Minor	Moderate	Major
	>50%	Moderate	Major	Major

Figure A.1 illustrates that at the time of implementation of a drought order / permit, upland river systems of relevance to each of these proposed options will exhibit high sensitivity to changes in low flow (represented by Q_{95}, summer[4]) and very high sensitivity to changes in extreme low flow (represented by Q_{99}, summer). As illustrated by **Figure A.2**, lowland rivers of relevance to each of these proposed options are considered to be less sensitive to reductions in summer low flows (summer Q_{95}), but similarly sensitive to reductions in extreme summer low flows (summer Q_{99}).

Figures A.1 and **A.2** are appropriate for the assessment of hydrological impacts on low flow regimes in watercourses during the spring, summer and autumn. However, in some cases there is a need to assess the impacts of drought order schemes on watercourses during the winter. For example, a reduction in compensation release may remain in force during the winter high flow period, to increase the probability of reservoir refill prior to the following year's spring/summer drawdown period. During the winter season, watercourses have relatively lower sensitivity to changes in low flow, and moderate sensitivity to changes in moderate flow. This can be reflected by the use of the matrices in **Figures A.3** and **A.4** for the assessment of drought order / permit schemes which are only likely to impact on a watercourse during the winter. The categorisation of impacts as negligible, minor, moderate or major is based on the percentage reduction in year round low flow (Q95) and year round median flow (Q50).

Figure A.3 Hydrological Assessment Matrix (Upland / Winter)

		Year round Q95		
	% reduction in flow	<10%	10-25%	>25%
Year round Q50	<10%	Negligible	Minor	Moderate
	10-25%	Minor	Moderate	Major
	>25%	Moderate	Major	Major

[4] Flow statistics indicate the proportion of days a flow is equalled or exceeded. Therefore Q95 indicates flow equalled or exceeded on 95% of days in the measured record (equivalent to an average of 347 days per year)

Figure A.4 Hydrological Assessment Matrix (Lowland / Winter)

		Year round Q95		
	% reduction in flow	<10%	10-25%	>25%
Year round Q50	<20%	Negligible	Minor	Moderate
	20-50%	Minor	Moderate	Major
	>50%	Moderate	Major	Major

The matrices are used to identify 1) the overall study area – which extends downstream of the abstraction until the hydrological impact has reduced to negligible; 2) reaches with similar scales of impact within the overall study area; and 3) the scale of hydrological impact within each reach. Typically reaches have been delimited by the addition of flow from a significant tributary or discharge; although the similarity of geomorphological characteristics of the reach may also be important in reach specification. The matrices can be applied to a variety of upland or lowland catchments respectively including those dominated by groundwater, and can be applied until the tidal limit.

In addition to the information provided by summary flow statistics in the matrix, information on the timing, duration and relevant seasons of the drought order / permit impacts have been informed by licence details and river gauging data have also been used to characterise the likely nature of the drought order / permit impacts.

If the drought order / permit does not impact on the magnitude of low flows in a watercourse, but does cause changes in the duration of low flow periods (which can be quantified), then the matrix in **Figure A.5** may be appropriate. The assessment is based on the percentage increase in the number of days for which flow is at or below the low flow (Q95) value. Typically this would be the case when the low flow regime in a watercourse downstream of a reservoir is protected by a statutory compensation release from the reservoir, but the reservoir may be drawn down below top water level for longer periods due to increased direct abstraction under the drought order / permit conditions.

If low flows in a watercourse are adversely affected in both magnitude and duration, then the impacts on magnitude are always used to determine the significance of hydrological impacts, using the appropriate matrix from **Figures A.1** to **A.4** inclusive. **Figure A.5** is only used when the impacts on low flows are on duration only.

Figure A.5 Hydrological Assessment Matrix (Low Flow Duration)

Percentage increase in low flow duration	Significance
<5%	Negligible
5-10%	Minor
10-25%	Moderate
>25%	Major

Intermittently flowing watercourse hydrological methodology

This methodology is applied to watercourses, potentially impacted on by the drought order / permit, that flow for most of the time but seasonally or occasionally ceasing to flow in response to decreased water availability e.g. due to increased evapotranspiration or bed seepage. . Such watercourses are identified from previous investigations and available data. Examples of watercourses where this methodology would be applied include winter bournes or watercourses that dry along their route due to losses to underlying aquifers. The impact classification of this methodology is as follows:

- Major - If the drought order / permit resulted in sections drying that did not dry up anyway
- Moderate - If the drought order / permit resulted in sections drying earlier (by more than a week) and / or recovering later (by more than a week) and hence flow reduction occurring in the channel for more than a week
- Minor - If the drought order / permit resulted in sections drying earlier (up to a week) and/or recovering later (by up to a week) and hence flow reduction occurring in the channel for up to a week OR if the drought order / permit were a secondary flow driver (e.g. flow through gravels being primary cause of flow losses rather than the drought order / permit)
- Negligible - No significant impact

In addition to the derived classifications, information on the timing, duration and relevant seasons of the drought order / permit impacts have been informed by licence details, available data and findings of previous investigations. These have been used to characterise the likely nature of the drought order / permit impacts.

Reservoir hydrological methodology

More recently Cascade has developed a similar approach to categorise the significance of hydrological impacts of drought order / permit operations on reservoirs. The assessment requires an estimate of the relative change in duration of reservoir drawdown (i.e. the period for which water in the reservoir is below top water level), and the percentage decrease in the minimum reservoir level reached during the drawdown period. These two parameters are then compared against the reservoir impacts hydrological assessment matrix in **Figure A.6**.

This approach would be a suitable method to assess the impacts of a drought order / permit which involves significant changes to the reservoir water level regime (that would not normally be experienced during a drought without any additional measures implemented). For example, a drought order / permit may involve increasing daily or annual licensed abstraction limits to allow an increased rate of direct abstraction from the reservoir. This may enable some or all of a reservoir's emergency storage volume to be utilised, but is likely to lead to both lower water levels and increased periods of time below top water level.

Figure A.6 Hydrological Assessment Matrix (Reservoir Impacts)

	% Increase in duration of reservoir drawdown			
% Decrease in minimum reservoir level	<5%	5-10%	10-25%	>25%
<5%	Negligible	Negligible	Minor	Moderate
5-10%	Negligible	Minor	Moderate	Major
10-25%	Minor	Moderate	Major	Major
>25%	Moderate	Major	Major	Major

Additional Considerations

For groundwater schemes, hydrogeological data, where available, has been reviewed to inform the study area and duration of any impacts (noting impacts on groundwater may extend beyond the six month period of drought order / permit implementation - see below). An increase in groundwater abstractions would lead to an increased cone of depression in groundwater levels for groundwater abstraction. This impact can affect other non-surface water receptors such as other wells, springs or groundwater dependent ecosystems. It could also mean that surface water impacts would extend upstream of the abstraction point or, in significant instances, to other watercourses some distance from the abstraction.

For groundwater abstractions, the impact of a drought order / permit could extend beyond the six month period (time limited) of abstraction depending on the local hydrogeology of the area. During drought situations, where there is limited recharge to the aquifer system, the abstraction can be mainly at the expense of groundwater stored in the aquifer. This can, in the long run, delay groundwater level recovery and have a knock on effect on baseflow contributions to watercourses. Flows could, therefore, be reduced for longer than the six month period during which the drought order / permit could be implemented and, as such, has been considered as part of the assessment described in this report.

APPENDIX B
HYDROLOGY AND PHYSICAL ENVIRONMENT ASSESSMENT

B1 INTRODUCTION

This appendix assesses the potential impacts on the physical environment of Llyn Bodlyn reservoir and the Afon Ysgethin river catchment during the period of implementation of the drought order and subsequent reservoir level recovery.

For the purposes of this assessment, the "without drought order" baseline includes the continuation of abstraction and statutory rate of compensation flow release (2.18Ml/d) under the existing abstraction licence for Llyn Bodlyn Reservoir. This represents normal operating arrangements during a typical summer/autumn period. The assessed drought order assumes a temporary reduction in the compensation flow rate of 1Ml/d (from 2.18 Ml/d to 1.18Ml/d) to conserve storage in Llyn Bodlyn Reservoir.

B.1.1 Welsh Water's Existing Operations

Welsh Water's licence (number 23/64/15/9) to abstract water under the Water Resources Act 1991 at Llyn Bodlyn (see **Figure B1.1**) includes the following conditions:

- 980 million litres (Ml) authorised to be abstracted per annum
- At an abstraction rate not exceeding 3.0Ml/d[1], with provision to increase to 3.5 Ml/d on any 14 days during the year
- Subject to the Barmouth Local Board Act 1891, which requires the discharge of a compensation flow (equivalent to a continuous daily release) of 2.18Ml/d to the Afon Ysgethin.

The abstraction for public water supply is made directly from the reservoir and piped 5km by gravity to the local water treatment works (WTW) at Eithyn Fynydd for treatment and distribution. Abstraction under gravity can be achieved to a maximum drawdown level of 3.2m below the reservoir spillway crest level.

Compensation flow releases are controlled through a notched weir system. At high reservoir levels (above the spillway crest level), excess water overflows (spills) from the reservoir to the Afon Ysgethin down a 3m wide spillway.

B.1.2 Welsh Water's Proposed Drought Order Operations

The drought order involves a proposed reduction in the statutory compensation flow release from Llyn Bodlyn to the Afon Ysgethin from 2.18Ml/d to 1.18Ml/d. This would conserve the longevity of reservoir storage for use in direct supply during a drought and improve the probability of reservoir winter refill. The drought order will potentially influence the downstream Afon Ysgethin.

The timing of the reduction in the compensation flow release is most likely to occur during the

[1] 1Ml/d is 1 million litres per day.

period from July to October inclusive. This is based on modelling of the Llyn Bodlyn reservoir performance under normal operating conditions in dry summers, together with experience of operating the source. Water resources modelling by Welsh Water using its WRAPSim computer model has indicated that the reduction in compensation flow release would be required for around 12 weeks in drought conditions.

The study area is shown on **Figure B1.1**.

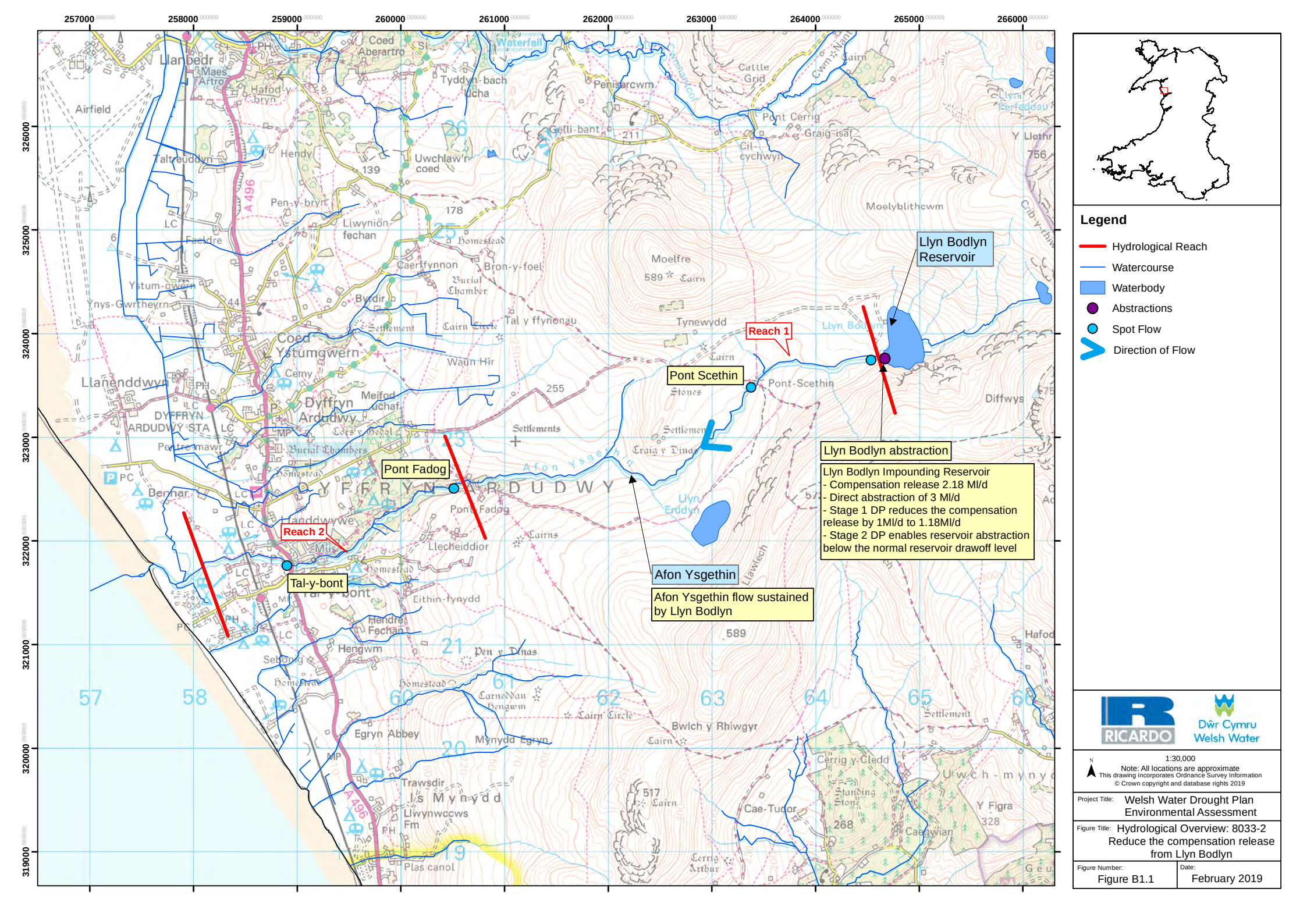
The physical environment includes consideration of hydrology and hydrodynamics; geomorphology; and water quality. The assessment has three principle objectives:

1. To "list the likely impacts to the flow, level, channel/riparian form and sediment due to action being in place" as required by the DPG[2] and set out in Figure 2 of the DPG.
2. It is used to support the screening and assessment of sensitive features (including ecological features and designated sites) as required by the DPG and set out in Section 5 of this report.
3. Where sensitive features are the physical environment itself, it provides supporting technical information for their screening and assessment.

This appendix is set out in the following sections:

Section B.2 Hydrological Impact
Section B.3 Physical Environment Assessment
Section B.4 Physical Environment Impact Summary
Section B.5 Cumulative Impacts.

[2] Natural Resources Wales (2017) *Water Company Drought Plan Technical Guideline*. Available at https://cdn.naturalresources.wales/media/684414/final-wc-drought-plan-guidance-2017.pdf?mode=pad&rnd=131656713580000000, Accessed 04 February 2019.


Llyn Bodlyn Reservoir
Reach 1
Pont Scethin
Llyn Bodlyn abstraction
Llyn Bodlyn Impounding Reservoir
- Compensation release 2.18 Ml/d
- Direct abstraction of 3 Ml/d
- Stage 1 DP reduces the compensation release by 1Ml/d to 1.18Ml/d
- Stage 2 DP enables reservoir abstraction below the normal reservoir drawoff level
Pont Fadog
Reach 2
Tal-y-bont
Afon Ysgethin
Afon Ysgethin flow sustained by Llyn Bodlyn
Legend
Hydrological Reach
Watercourse
Waterbody
Abstractions
Spot Flow
Direction of Flow
1:30,000
Note: All locations are approximate
This drawing incorporates Ordnance Survey Information
© Crown copyright and database rights 2019
Project Title: Welsh Water Drought Plan Environmental Assessment
Figure Title: Hydrological Overview: 8033-2 Reduce the compensation release from Llyn Bodlyn
Figure Number: Figure B1.1
Date: February 2019

B2 HYDROLOGICAL AND HYDROGEOLOGICAL IMPACT

B.2.1 Reference Conditions

B.2.1.1 Catchment Overview

Llyn Bodlyn and the Afon Ysgethin catchment are located in north west Wales, rising in the Rhinog Mountains and flowing to Cardigan Bay around 6km north-west of Barmouth.

In 1894, the reservoir impoundment extended the area and depth of the previous natural glacial lake, Llyn Bodlyn, behind a 5m high stone embankment at an altitude of 382m. Llyn Bodlyn reservoir has a surface area of approximately 19ha (at top water level) and a maximum storage capacity of 439Ml. The reservoir is fed by a mountainous headwater catchment, 3.7km^2 in area. Water is abstracted directly from the reservoir for treatment at the Eithyn Fynydd WTW and supply to the Barmouth Water Resource Zone (average demand 1.50Ml/d, peak week demand 2.31Ml/d in 2012/13).

The Afon Ysgethin is joined by a small tributary river approximately 3km downstream of Llyn Bodlyn and also receives outflows from Llyn Erddyn, a natural lake to the south-west. Afon Ysgethin has a catchment area of 14.3km^2 at the tidal limit, and Llyn Bodlyn is the only licensed abstraction within the catchment.

Llyn Bodlyn and the Afon Ysgethin are located within Snowdonia National Park. Approximately 2km of the lower Afon Ysgethin flows through an area designated as a Special Area of Conservation (SAC) (the Coedydd Derw a Safleoedd Ystlumod Merion SAC) and through a Site of Special Scientific Interest (SSSI) (Coed Cors y Gredol SSSI), which is located just upstream of the tidal limit at Tal-y-Bont.

B.2.1.2 Baseline Data Availability

Continuous monitoring is undertaken by Welsh Water to monitor its operations at Llyn Bodlyn Reservoir, including:

• Weekly Llyn Bodlyn water level data: 1982 to present (daily from 2001)

• Daily Llyn Bodlyn compensation flow data: 1995 to present

• Daily Llyn Bodlyn abstraction flows: 2005 to present.

There is no continuous measurement of the Afon Ysgethin stream flow downstream of the Llyn Bodlyn Reservoir, and reservoir overflows, which occur when reservoir storage is at top water level, are not measured.

The reference conditions of Llyn Bodlyn reservoir are summarised below, based on the available hydrological data as set out above.

B.2.1.3 Hydrology

Llyn Bodlyn Reservoir

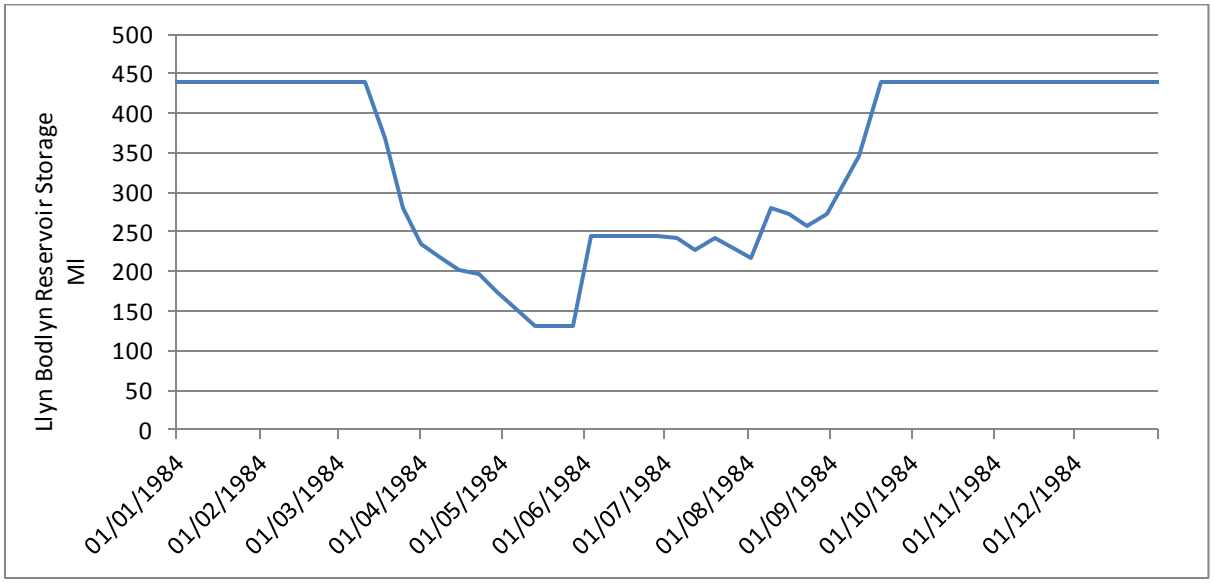
Typically, reservoir water levels range from about 3m to about 5m (1982 - 2015) above datum in Llyn Bodlyn. The top water level is at 5m above datum and when the reservoir is at full capacity, any overflows pass down the spillway channel into Afon Ysgethin. A summary of reservoir levels is given in **Table B2.1** below. Minimum reservoir levels over the period 1982 to 2015 are 1.8m above datum (occurring in May 1984), equating to a water level drawdown of 3.2m below top water level.

Table B2.1 Summary of Recorded Mean Daily Reservoir Level in Llyn Bodlyn Reservoir (1982 - 2015)

Percentage of time lake level equalled or exceeded	Mean daily reservoir level (metres above datum) per month												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	All year
Maximum reservoir level	5.5	5.4	5.9	5.4	5.7	5.6	5.3	5.4	5.4	5.3	5.3	5.3	5.9
10% (high level)	5.2	5.2	5.2	5.1	5.2	5.1	5.1	5.1	5.2	5.2	5.1	5.2	5.2
50%	5.1	5.1	5.0	5.0	5.0	5.0	5.0	5.1	5.0	5.1	5.1	5.1	5.1
80%	5.0	5.0	5.0	4.9	4.9	4.9	4.9	5.0	5.0	5.0	5.0	5.0	5.0
90%	5.0	5.0	5.0	4.8	4.8	4.7	4.8	4.8	4.9	4.9	5.0	5.0	4.9
95%	4.9	4.9	4.9	4.7	4.7	4.5	4.7	4.6	4.7	4.8	4.6	4.9	4.7
99% (low level)	4.6	4.8	4.8	4.2	4.4	4.3	4.5	4.2	4.5	3.1	3.2	4.4	4.2
Minimum reservoir level	3.0	3.6	4.0	3.3	1.8	3.8	3.7	3.6	4.3	2.3	2.4	2.5	1.8

Figure B2.1 illustrates the drawdown patterns in Llyn Bodlyn Reservoir in the relatively severe drought of 1984. The lowest levels of 1.8-2.5m are understood to be due to reservoir drawdown for dam maintenance works.

Figure B2.1 Llyn Bodlyn Reservoir Storage (1984)



Abstractions from the reservoir to supply Eithinfynydd WTW have typically been in the range 1 – 3Ml/d over the past ten years.

Afon Ysgethin

The Afon Ysgethin is about 10km long, with a catchment area of 14.3km^2 at its tidal limit. At the Llyn Bodlyn reservoir spillway weir, the catchment area is 3.7km^2. The compensation flow release from the reservoir is measured, however reservoir overflows which occur when the reservoir is at full capacity are not measured.

The statutory compensation requirement is for a daily release of 2.18Ml/d. Recorded flows are generally in the range 2 – 4Ml/d.

Other than the compensation flow record, there is very little measured flow data available for the Afon Ysgethin. A limited number of spot flow gauging results are available from surveys undertaken in 2011[3] and 2012[4] respectively; the locations and dates of these surveys are given in **Table B2.2** below. Note that the sites numbered 2, 4 and 8 in the 2011 surveys are in similar locations as the sites with the same numbers in 2012, so the flow results for the corresponding site numbers are broadly comparable. **Tables B2.3** and **B2.4** present the hydrometric parameters recorded at all sites during the surveys of 2011 and 2012 respectively.

Table B2.2 Afon Ysgethin Spot Flow Gauging Survey Locations, 2011 and 2012

Site	Location	NGR	Dates Surveyed
Site 2 (2011)	Afon Ysgethin at Pont Scethin	SH63502350	31 August 2011
Site 4 (2011)	Afon Ysgethin at Pont Fadog	SH60702260	31 August 2011
Site 8 (2011)	Afon Ysgethin at Tal-y-bont (tidal limit)	SH59002190	31 August 2011

[3] Dŵr Cymru Welsh Water Environmental Assessment of Llyn Bodlyn Reservoir Drought Order, AMEC, January 2012

[4] Dŵr Cymru Welsh Water Environmental Monitoring Studies for the Llyn Bodlyn Reservoir (N8) Drought Order, Cascade, January 2013

Site 2 (2012)	Afon Ysgethin at Pont Scethin	SH6345923574	12 April 2012 25 July 2012
Site 4 (2012)	Afon Ysgethin at Pont Fadog	SH6074222592	12 April 2012 25 July 2012
Site 8 (2012)	Afon Ysgethin at Tal-y-bont (tidal limit)	SH5898121767	12 April 2012 25 July 2012

Source: Amec 2012 and Cascade 2013

Table B2.3 Afon Ysgethin Spot Flow Gauging Results, 2011

Date	Location	Grid Reference	Spot Flow, m^3/s	Spot Flow, Ml/d	Mean Velocity, m/s	Cross-Sectional Area, m^2
31.8.2011	Afon Ysgethin at Pont Scethin	SH63502350	0.131	11.3	0.294	0.446
31.8.2011	Afon Ysgethin at Pont Fadog	SH60702260	0.277	23.9	0.370	0.737
31.8.2011	Afon Ysgethin at Tal-y-bont (tidal limit)	SH59002190	0.295	25.5	0.342	0.863

Source: Amec 2012

Table B2.4 Afon Ysgethin Spot Flow Gauging Results, 2012

Date	Location	Spot Flow, Ml/d	Wetted Width (m)	Wetted width with depth greater than 0.1m (m)	Maximum Depth (m)	Mean Velocity, (m/s)	Maximum Velocity (m/s)
12.04.2012	Site 2	9.9	2.8	2.3	0.25	0.19	0.63
25.07.2012	Site 2	9.0	5.6	5.2[5]	0.90[6]	0.11	0.27
12.04.2012	Site 4	28.6	6.8	4.6	0.45	0.17	0.66
25.07.2012	Site 4	27.2	6.9	4.3	0.32	0.21	0.89
12.04.2012	Site 8	27.2	7.6	6.4	0.34	0.20	0.92
25.07.2012	Site 8	33.8	7.5	5.3	0.36	0.27	0.60

Source: Cascade 2013

An overall summary of flows recorded during both surveys, together with the relevant catchment areas, is given in **Table B2.5.**

Table B2.5 Summary of 2011 and 2012 Spot Flow Monitoring Results

Site	Catchment Area (km^2)	Date/Flow (Ml/d)		
		31.08.2011	12.04.2012	25.07.2012
Site 2	6.1	11.3	9.9	9.0
Site 4	12.8	23.9	28.6	27.2
Site 8	14.3	25.5	27.2	33.8

The flow values in **Table B2.5** indicate that there is considerable flow accretion between Pont Scethin in the upper part of the river below the reservoir and Pont Fadog and probably some limited flow accretion between Pont Fadog and Tal-y-bont. However none of these spot gauging results are thought to correspond to a particularly low flow period within the catchment; on all three spot gauging occasions, Llyn Bodlyn was recorded as being at full

[5] It is noted that the wetted width at Site 2 was greater during the July survey than the April survey, although the flow was lower during the July event. The reasons for this are not fully known, although flood events between surveys may have resulted in a change to the cross-section profile in this period.
[6] It is noted that the maximum depth at Site 2 was greater during the July survey than the April survey, although the flow was lower during the July event. The reasons for this are not fully known, although flood events between surveys may have resulted in a change to the cross-section profile (particularly bed substrate) in this period.

capacity and therefore presumably overflows would have been occurring. These catchment flows are therefore not representative of the low flow regime which is likely to be occurring during the period of implementation of a drought order.

B.2.2 Hydrological Impact

B.2.2.1 Hydrological Zone of Influence

A review of the flows and physical habitat characteristics of the river network downstream of Llyn Bodlyn Reservoir has identified the likely hydrological zone of influence of the drought order, which has been used to define the study area. The study area includes the Afon Ysgethin, comprising two distinct hydrological reaches, as shown on **Figure B1.1**:

- Reach 1 is the Afon Ysgethin, from the Llyn Bodlyn reservoir outflow to Pont Fadog.
- Reach 2 is the Afon Ysgethin, from Pont Fadog to the tidal limit.

The potential hydrological impacts of the drought order options have been assessed for Llyn Bodlyn Reservoir and the two separately identified river reaches, as summarised in **Table B2.6** and **Table B2.7** at the end of this section.

The details of the assessment for each reach are presented below.

B.2.2.2 Hydrological Impact Assessment

Llyn Bodlyn Reservoir

The impact on Llyn Bodlyn Reservoir would be a marginal increase in water levels/reservoir storage relative to the position without the drought order due to the reduced compensation flow release which would help to conserve reservoir storage. The duration of shoreline exposure due to reservoir drawdown would be slightly shorter, compared to the baseline drought scenario, as the reservoir would reach top water level slightly earlier during the winter refill period. This would be considered as a minor positive impact and has not been assessed further.

River Reach Assessment

In the absence of any gauged flow data in the downstream Afon Ysgethin catchment, simulated catchment flows have been used as provided by Welsh Water (from its WRAPSim water resources model of the Llyn Bodlyn system) to estimate key flow statistics at locations on the Afon Ysgethin downstream of the reservoir outflow. Flow accretion proportions of the simulated reservoir inflow daily record have been estimated, based on relative catchment areas, and these have been added to the statutory compensation flow. The estimated summer low flow statistics for the Afon Ysgethin at Pont Fadog are 6.0Ml/d (Q_{95}) and 4.9Ml/d (Q_{99}), whilst the year round flow statistics at this location are 6.6Ml/d (Q_{95}) and 24.4Ml/d (Q_{99}).

Reach 1 – Afon Ysgethin (Llyn Bodlyn Reservoir Outflow to Pont Fadog)

Reach 1 is the 4.8km stretch of the Afon Ysgethin as it flows across the moorland area between Llyn Bodlyn and the bridge (Pont Fadog) at SH607226. Some flow accretion is provided from small tributaries including the outflow from Llyn Erddyn, a natural lake to the south of the main watercourse.

Llyn Bodlyn Reservoir will not be at full capacity when a drought order is implemented, therefore no overflow (spill) will be occurring and the only outflow from the reservoir will be the compensation flow release. The reduction in compensation flow rate from 2.18Ml/d to 1.18Ml/d therefore represents a 46% reduction in summer low and extreme low flows in the upper Afon Ysgethin immediately below the reservoir. Similarly if the drought order continues to be required during the winter month of October, the reduction in flow from 2.18Ml/d to 1.18Ml/d still represents a 46% reduction in year round low and median flows.

The hydrological impact of this drought order on Reach 1 is, therefore, assessed as **major** at any time of year.

Reach 2 – Afon Ysgethin (Pont Fadog to tidal limit)

The Afon Ysgethin in Reach 2 is an incised channel with a steep gradient (1 in 13) and extends from Pont Fadog to the tidal limit at Tal-y-bont. The steep gradient of this reach and the narrow boulder/cobble-bed river channel produce a cascade-pool effect, reducing the wetted depth sensitivity of the watercourse during episodes of low flow.

The impact of the reduced compensation flow release on Reach 2 is similar to that on Reach 1, except that there would be some further flow accretion in the Afon Ysgethin between the reservoir outflow and the end of Reach 1 at Pont Fadog. The estimated summer flow statistics for the Afon Ysgethin at Pont Fadog are 6.0Ml/d (Q_{95}) and 4.9Ml/d (Q_{99}), and therefore a flow reduction of 1Ml/d represents a percentage reduction of 16.7% and 20.4% respectively, at the top of Reach 2. The hydrological impact of this drought order on Reach 2 is, therefore, assessed as **moderate** during the summer months of July to September inclusive.

During the winter month of October, the estimated low and median year round flow statistics for the Afon Ysgethin at Pont Fadog are 6.6Ml/d (Q_{95}) and 24.4Ml/d (Q_{50}). The 1Ml/d flow reduction of 1Ml/d therefore represents percentage reductions of 15.2% and 4.1% in the low and median flow values respectively. The hydrological impact of the drought order is therefore assessed as **minor** during October.

B.2.2.3 Hydrological Impact Summary

Two reaches have been considered for which the assessed hydrological impacts range from **moderate** to **major** during the summer months of July to September, and from **minor** to **major** during the month of October. The impacted reaches are shown in **Table B2.6** and **Table B2.7** and establish the full in-channel zone of influence of the drought order for environmental sensitivity screening (see **Figure B1.1**).

The impact on Llyn Bodlyn Reservoir itself has been assessed as **minor positive**.

Table B2.6 Hydrological and Monitoring Reaches Identified in the Study Area – Summer Impact (July to September)

Hydrological Reach		Reach boundary		Reach length	% flow reduction		Hydrological Impact - summer
		Upstream	Downstream		Summer Q_{95}	Summer Q_{99}	
Llyn Bodlyn Reservoir		n/a	n/a	n/a	n/a	n/a	**Minor positive**
1	Afon Ysgethin	Llyn Bodlyn Reservoir Outflow	Pont Fadog	4.8km	46%	46%	**Major**
2	Afon Ysgethin	Pont Fadog	Tidal limit	3.3km	16.7%	20.4%	**Moderate**

Table B2.7 Hydrological and Monitoring Reaches Identified in the Study Area – Winter Impact (October)

Hydrological Reach		Reach boundary		Reach length	% flow reduction		Hydrological Impact - winter
		Upstream	Downstream		Year round Q_{50}	Year round Q_{95}	
Llyn Bodlyn Reservoir		n/a	n/a	n/a	n/a	n/a	**Minor positive**
1	Afon Ysgethin	Llyn Bodlyn Reservoir Outflow	Pont Fadog	4.8km	46%	46%	**Major**
2	Afon Ysgethin	Pont Fadog	Tidal limit	3.3km	4.1%	15.2%	**Minor**

B3 PHYSICAL ENVIRONMENT ASSESSMENT

B.3.1 Geomorphology and Sediment Transport

B.3.1.1 Hydrological Reaches

The Afon Ysgethin catchment is relatively steep; it falls from 138m AOD to sea level in around 8km and consists of a rocky channel with occasional gorges, waterfalls and natural boulder weirs. The predominant land use is unimproved moorland in the upper catchment, and woodland and urban development below Pont Fadog. A walkover survey undertaken in summer 2011 noted only a few gravel bed areas in the lower river reach, and undercutting of the banks was noted only in one short reach of around 50m length.

There is limited geomorphology data available for the Afon Ysgethin catchment; there is just one NRW River Habitat Survey (RHS) site (13110) in the wooded gorge of Reach 2. Review of the data for this site indicates a pristine, unmodified watercourse (a Habitat Modification Score (HMS) of 0) developed in boulder clay and moranic drift and underlain by a Lower Cambrian lithology. Channel bed substrate at the site was formed from 80% cobble and 20% boulder; bank material is earth, with boulder forming some of the bank material. Flow type is dominated by broken standing waves. Channel width was recorded as 11m with channel banktop height recorded as 0.4m. Tree cover was recorded as continuous broad-leaved on both banks.

There are no obvious sources of sediment to the river, particularly in the upper catchment, and minimal sediment loading would be likely during low flow periods.

Reach 1 - Afon Ysgethin

Reach 1 is the 4.5km stretch of the Afon Ysgethin as it flows across the moorland area between Llyn Bodlyn (see Plate 1) and the bridge (Pont Fadog) at SH607226 (see Plate 2). The channel bed substrate is boulder and cobble throughout. Although isolated from sources of fine and coarse sediment by the Llyn Bodlyn impoundment, such sediment is supplied by bank erosion within Reach 1 and input from 1st order streams. Typical river channel width in this reach is 3m, increasing to 5m at the frequent braided channel sections which occur with the low gradient. The dominant land cover in Reach 1 is acid grass and bracken.

Reach 2 - Afon Ysgethin

The Afon Ysgethin in Reach 2 is an incised channel with a steep gradient (1 in 13) and extends from Pont Fadog to the tidal limit. Typical river channel width in this reach is 6-8m. The dominant land cover in the lower catchment is improved grassland. The section between Pont Fadog (see Plate 2) and the A496 road bridge (see Plate 3) being a narrow, wooded gorge. The steep gradient of this reach and the narrow boulder/cobble-bed river channel produce a cascade-pool effect, reducing the wetted-depth sensitivity of the watercourse during episodes of low flow. Bed erosion, during incision, and bank erosion, acts as the predominant sediment sources in Reach 2.

During times of low river flow in Reach 2, the contribution of the Llyn Bodlyn compensation component to flow is not known but assumed to be significant. This would result in a reduction in wetted width and wetted depth below those normally observed.

Plate 1: Afon Ysgethin (from SH645238 looking east) with Llyn Bodlyn em bankment in the upper left.

Plate 2: Afon Ysgethin looking upstream from Pont Fadog

Plate 3: Afon Ysgethin looking upstream from the A469 road bridge

B.3.1.2 Conclusions

In drought conditions, it is assumed that no significant geomorphological activity (i.e. erosion or transport or depositional processes) will be occurring within the catchment or river and sediment supply to the river is likely to be negligible.

Significant changes to sediment transport or geomorphology are considered unlikely for the following reasons:

- The majority of sediment transport and morphological change is likely to occur at high flows and when the reservoir is overflowing (spilling). The magnitude and frequency of these flows will not be affected by the proposed compensation flow reductions;
- Prolonged periods of low flow could in theory result in additional deposition of fine sediment over coarse channel substrate, e.g. the few areas of gravel beds identified during walkover surveys. However, this is considered unlikely, since there are few sources of fine sediment in the study reach that would be mobilised under low flows (e.g. sewage treatment works discharges), and low flow conditions would already occur in the baseline;
- Reductions in wetted perimeter could in theory lead to drying and destabilisation of the channel margins, resulting in excess erosion once high flows resume. However, a significant effect is considered to be highly unlikely, given the relatively short duration of flow reductions (estimated at up to 12 weeks by modelling), and that any significant flow reductions would occur only at low flows at which the channel dimensions and velocity would be well within the bankfull width already.

Therefore, it is concluded that the impact of the drought order on sediment dynamics and bank erosion in both reaches is **negligible**.

B.3.2 Water Quality

This section sets out the baseline water quality and examines changes over time and with respect to river flows. Environmental pressures on river water quality (such as discharges from wastewater treatment works (WwTWs)), which may cause increased deterioration in water quality with the drought order in place, are discussed separately in Section B.3.3.

To support the assessment of potentially sensitive environmental features (see Section 5 of the main report), an understanding has been developed of the water quality of the rivers within the zone of influence of the drought order, including trends over time and with respect to river flow. For WFD classification, the Environment Agency has set out[7] following UKTAG evidence[8] what pressures, including water quality pressures, each biological quality element is capable of responding to. For the purposes of assessment here, the supporting water quality parameters are set out: for fish and macroinvertebrates (where identified as sensitive features) as dissolved oxygen saturation and total ammonia concentration; and for macrophytes and algae (phytobenthos / diatoms) (where identified as sensitive features) as soluble reactive phosphorus (SRP). Specifically, for macrophytes, if the hydrological impacts of drought order implementation have been identified within the main macrophyte growing season (April to September), an assessment of SRP has been undertaken.

Potential impacts on other water quality parameters, such as temperature, have been considered where appropriate (e.g. temperature influences dissolved oxygen and if sufficient information is available on dissolved oxygen and is being reviewed it may not be necessary to undertake a separate temperature assessment). Where data are lacking, the assessment has been undertaken using professional judgement.

Ten years of EA routine monitoring data were reviewed to provide an overview of water quality in the hydrological zone of impact. On the Afon Ysgethin, within the extent of influence of the drought order, there are two EA water quality sampling sites: 1 on Reach 1 (Llyn Bodlyn near Overflow) and 1 on Reach 2 (Afon Ysgethin at Tal-Y-Bont) (**Table B3.1** and **Figure B1.1**). Data are available for these sites (2007 to 2015) and include measurements of a suite of parameters.

Where data are lacking the assessment has been undertaken using professional judgement. Values at the limit of detection were halved in line with standard Environment Agency/NRW practice.

[7] Environment Agency (2011) Method statement for the classification of surface water bodies v2.0 (external release) Monitoring Strategy v2.0 July 2011 Table 2
[8] UK Technical Advisory Group on the Water Framework Directive (2008) Recommendations on Surface Water Classification Schemes for the purposes of the Water Framework Directive December 2007 (alien species list updated – Oct 2008 and Nov 2008). Appendix 1

Table B3.1 Details of NRW Water Quality Sampling Points on the Afon Ysgethin

Reach	Site Name	NRW Site Code	Grid reference	Location
1	Llyn Bodlyn near Overflow	26359	SH6470023800	Llyn Bodlyn overflow
2	Afon Ysgethin at Tal-Y-Bont	28182	SH5894021765	Tal-Y-Bont

Reach 1 – Afon Ysgethin (Llyn Bodlyn Reservoir Outflow to Pont Fadog)

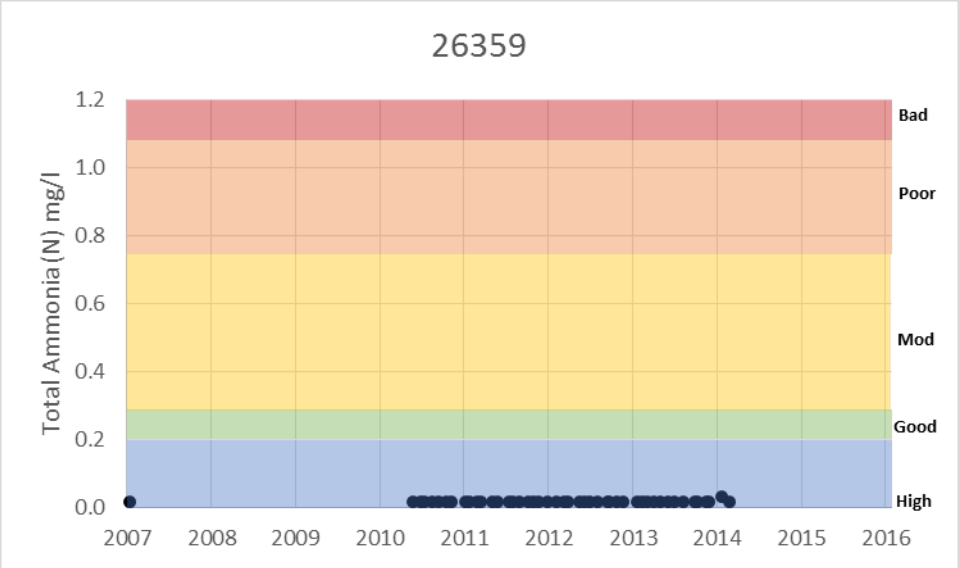
Water quality data are available for one NRW monitoring point near Reach 1 (major hydrological impact): Llyn Bodlyn near Overflow (site 26359).

The monitoring site Llyn Bodlyn near Overflow represents the upstream section of Reach 1. The average pH at Llyn Bodlyn near Overflow over the ten year review period was 6.6 and the maximum water temperature was 18.6°C.

Total Ammonia Concentration

Total ammonia concentrations on the Afon Ysgethin at Llyn Bodlyn near Overflow were reviewed and data presented in **Figure B3.1** against the relevant WFD standards for an upland low alkalinity river[9].

Figure B3.1 Total Ammonia at Llyn Bodlyn near Overflow, Incorporating Appropriate WFD Status Bands



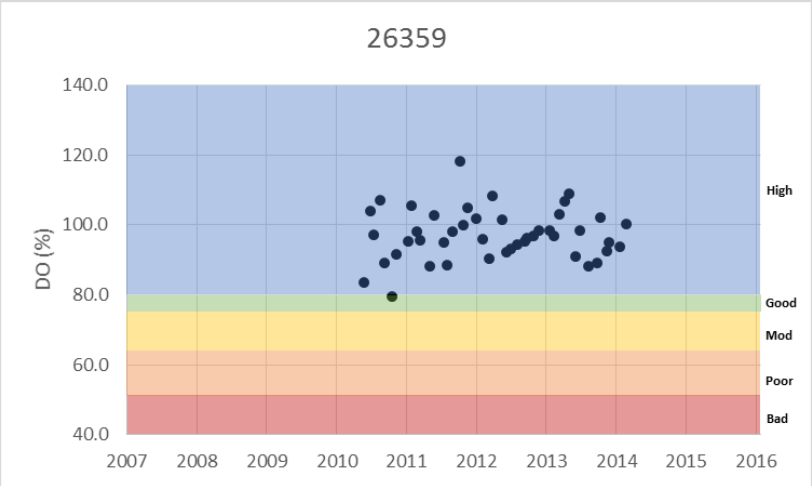
Total ammonia concentrations on the Afon Ysgethin at Llyn Bodlyn near Overflow (see **Figure B3.1**) were all consistent with the WFD standard to support high status for fish and invertebrates (0.2mg/l).

[9] The River Basin Districts Typology, Standards and Groundwater threshold values (Water Framework Directive) (England and Wales) Directions 2010. ISBN 978-0-85521-192-9.

Dissolved Oxygen Saturation

Dissolved oxygen saturation data on the Afon Ysgethin at Llyn Bodlyn near Overflow were reviewed and data are presented in **Figure B3.2** against the relevant WFD standards for an upland low alkalinity river[10].

Figure B3.2 Dissolved Oxygen Saturation at Llyn Bodlyn near Overflow, Incorporating Appropriate WFD Status Bands



Dissolved oxygen saturation measurements on the Afon Ysgethin at Llyn Bodlyn (see **Figure B3.2**) were all consistent with the WFD standard to support high status for fish and invertebrates (80%).

Reach 2 – Afon Ysgethin (Pont Fadog to tidal limit)

Water quality data are available for one EA monitoring point on Reach 2 (moderate hydrological impact): Afon Ysgethin at Tal-Y-Bont (site 28182).

The monitoring site Afon Ysgethin at Tal-Y-Bont represents the downstream section of Reach 2. The average pH at Afon Ysgethin at Tal-Y-Bont over the ten year review period was 7.0 and the maximum water temperature was 16.6°C.

Total Ammonia Concentration

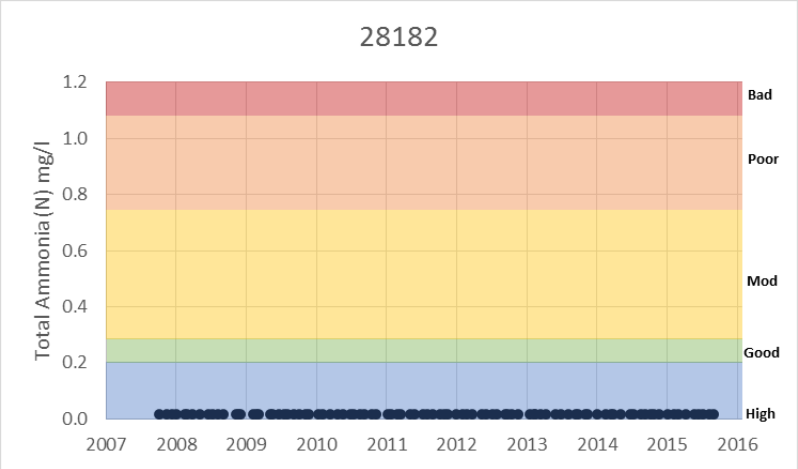
Total ammonia concentrations on the Afon Ysgethin at Tal-Y-Bont were reviewed and data presented in **Figure B3.3** against the relevant WFD standards for an upland low alkalinity river[11].

Total ammonia concentrations on the Afon Ysgethin at Tal-Y-Bont near Overflow (see **Figure B3.3**) were all consistent with the WFD standard to support high status for fish and

[10] The River Basin Districts Typology, Standards and Groundwater threshold values (Water Framework Directive) (England and Wales) Directions 2010. ISBN 978-0-85521-192-9.
[11] The River Basin Districts Typology, Standards and Groundwater threshold values (Water Framework Directive) (England and Wales) Directions 2010. ISBN 978-0-85521-192-9.

invertebrates (0.2mg/l).

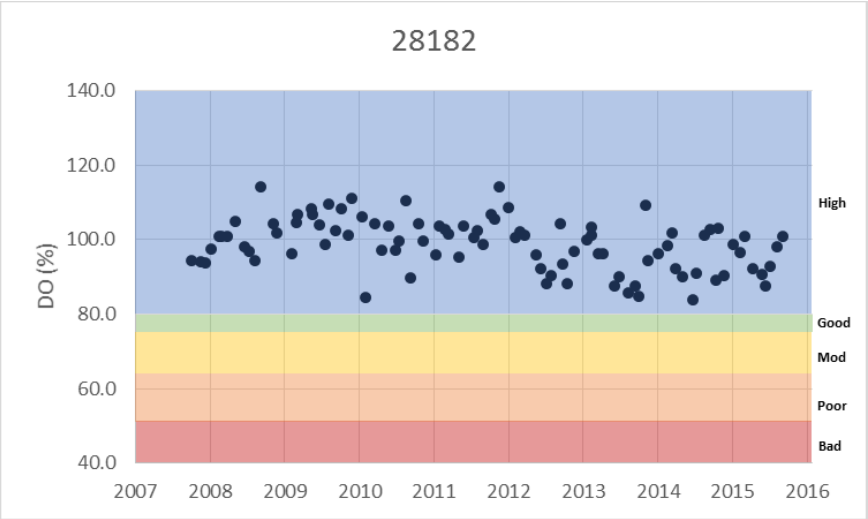
Figure B3.3 Total Ammonia at Afon Ysgethin at Tal-Y-Bont, Incorporating Appropriate WFD Status Bands



Dissolved Oxygen Saturation

Dissolved oxygen saturation data on the Afon Ysgethin at Tal-Y-Bont were reviewed and data are presented in **Figure B3.4** against the relevant WFD standards for an upland low alkalinity river[12].

Figure B3.4 Dissolved Oxygen Saturation at Afon Ysgethin at Tal-Y-Bont, Incorporating Appropriate WFD Status Bands



Dissolved oxygen saturation measurements on the Afon Ysgethin at Tal-Y-Bont (see **Figure B3.4**) were all consistent with the WFD standard to support high status for fish and invertebrates (80%).

[12] The River Basin Districts Typology, Standards and Groundwater threshold values (Water Framework Directive) (England and Wales) Directions 2010. ISBN 978-0-85521-192-9.

Water Quality Summary

Assessment of risk to water quality as a result of the Llyn Bodlyn drought order is limited by the spatial and temporal extent of the data available. Data received from NRW only cover the period January 2007 to December 2015.

Total ammonia concentrations were all consistent with the standard to support high status for fish and invertebrates throughout the zone of influence of the Llyn Bodlyn drought order. Seasonal variability in total ammonia concentration was low. The risk of the drought order to total ammonia concentration levels within the zone of influence is therefore **minor** in Reach 1 and Reach 2 of the Llyn Bodlyn drought order.

Dissolved oxygen saturations were all consistent with the standard to support high status for fish and invertebrates throughout the zone of influence of the Llyn Bodlyn drought order. The risk of the drought order to dissolved oxygen saturation levels within the zone of influence is therefore **minor** in Reach 1 and Reach 2 of the Llyn Bodlyn drought order.

No SRP assessment has been undertaken as the implementation of the drought order does not fall within the peak macrophyte growth season.

B.3.3 Environmental Pressures

B.3.3.1 Flow Pressures

No significant abstraction have been identified.

B.3.3.2 Water Quality Pressures

One water quality pressure has been identified in Reach 2 but discharge information for the small STW is unknown pending additional data (see **Table B3.2**).

Table B3.2 Summary of Water Quality Pressures

Discharge Name	Permit Number	Flow: Daily total (Ml/day)	Flow: DWF (Ml/day)	BOD: 5 Day ATU (mg/l)	Ammoniacal Nitrogen as N (mg/l)	Suspended Solids at 105 C (mg/l)	Water Quality Pressure
Eithinfynydd WwTW	-	Not specified	Not specified	Not specified	Not specified	Not specified	Negligible

B4 PHYSICAL ENVIRONMENT IMPACT SUMMARY

Potential impacts on the physical environment associated with the Llyn Bodlyn Reservoir reduced compensation release drought order are summarised in **Table B4.1.**

Table B4.1 Summary of Potential Changes to the Physical Environment of the Impacted Reaches from Implementation of Llyn Bodlyn Reservoir Reduced Compensation Release Drought Order

Afon Ysgethin (Reach 1)	
Flows in the Afon Ysgethin *Major impacts for up to 12 weeks during the period from July to October inclusive*	• Reductions of up to 46% in river flows with corresponding reductions in wetted depths/wetted widths (potential marginal habitats), during the summer and autumn period
Water quality in the Afon Ysgethin *Minor risk for up to 12 weeks during the period from July to October inclusive*	• Total ammonia and dissolved oxygen concentrations were all consistent with the standard to support high status for fish and invertebrates throughout the zone of influence of the Llyn Bodlyn drought order.
Surface water abstractions and risk to abstractors *Negligible risk*	• No surface water abstractions
Consented discharges *Negligible risk*	• No consented discharges
Geomorphology *Negligible risk*	• Significant changes considered unlikely.
Afon Ysgethin (Reach 2)	
Flows in the Afon Ysgethin *Moderate impacts during the period from July to September inclusive; minor impacts during the month of October*	• Reductions of up to 20.4% in river flows with corresponding reductions in wetted depths/wetted widths (potential marginal habitats), during the summer months of July to September; flow reductions of up to 15.2% in October
Water quality in the Afon Ysgethin *Minor risk for up to 12 weeks during the summer/autumn period*	• Total ammonia and dissolved oxygen concentrations were all consistent with the standard to support high status for fish and invertebrates throughout the zone of influence of the Llyn Bodlyn drought order.
Surface water abstractions and risk to abstractors *Negligible risk*	• No surface water abstractions
Consented discharges *Negligible risk*	• Small STW, consent limits unavailable but given physical size of the works it is unlikely to be greater than negligible risk.
Geomorphology *Negligible risk*	• Significant changes considered unlikely.

B5 CUMULATIVE IMPACTS

The focus of this EAR is the Llyn Bodlyn 8033-2 drought order. The assessment, as described in previous sections, has considered how the proposed drought order may affect the environment in combination with the effects of existing licences and consents. In accordance with the DPG the assessment also considers the potential cumulative effects of Welsh Water implementing other drought permits / orders within a similar timeframe. The potential for options to act in combination is set out in **Table B5.1**.

Consideration has also been given to the potential for cumulative impacts of drought options implemented by neighbouring water companies (see **Table B5.1**). The assessment of the potential for cumulative impacts of Welsh Water's supply side and drought permit / order options with drought options listed in neighbouring water companies' drought plans has also been undertaken as part of the Strategic Environmental Assessment (SEA) of Welsh Water's Draft Statutory Drought Plan. The SEA was informed by the most recent information available on the neighbouring water companies' drought plans.

Table B5.1 Cumulative Impacts of the Llyn Bodlyn Reservoir Drought Order with Other Drought Options

Organisation	Potential In-combination Impacts	Further Consideration Required (Yes/No)
Welsh Water - other drought options in the Barmouth WRZ	None	N/A
Natural Resources Wales - Drought options in the Afon Ysgethin catchment	No previous drought order applications have been made in the North Wales region.	No

APPENDIX C
ENVIRONMENTAL FEATURES ASSESSMENT METHODOLOGY

A.1 ENVIRONMENTAL FEATURES ASSESSMENT METHODOLOGIES

The assessments undertaken in the EARs will use available environmental data. The following methodologies detail the preferred approach to impact assessment for the sensitive receptors identified in the screening process.

However, in certain circumstances the supporting data on hydrological conditions, habitat availability and species occurrence may not be currently available. In these cases, other supporting data will be used, where available, and the assessment will be undertaken using expert judgement. An example may be where flow-induced river habitat for fish would ideally be defined through the total wetted area, depth and flow velocities to describe the habitat preferences of a species and its lifestages. Where these data are currently unavailable, the use of habitat walkover, RHS and / or aerial survey data may be used in combination with judgements on the hydrological change resulting from the drought option (e.g. reduction in river flows) to arrive at a statement on habitat reduction and consequent impact on the fish species. The analysis will detail the increased uncertainty prevalent in the approach and will therefore adopt a precautionary approach to impact prediction (possibly assigning a higher impact where fewer substantiating data are available).

The gaps in data and evidence will be noted and monitoring proposals established.

Assessment sheets are included for the following features:

- Flow pressures
- Water quality pressures.
- WFD Status: Fish
- WFD Status: Aquatic macroinvertebrates
- Environment (Wales) Act Section 7 species, designated sites and other sensitive fauna and flora.

FLOW PRESSURES

Potential Effects

In support of understanding the physical environment and the risk assessment in the zone of influence of each drought option, a review will be undertaken of additional flow pressures from licensed surface water and groundwater abstractions. Relevant pressures have been identified and risk assessed in terms of in-combination flow impacts from implementation of a drought option. Abstractions have the potential to exacerbate low river flows or, in the case of groundwater-dominated catchments where rivers seasonally run dry (ephemeral watercourses), to increase the length of river that is dry and the period of time for which it remains so, potentially beyond the period for which the drought option is in place.

As a result of a drought option, there may be less water available in the zone of influence (rivers and groundwater bodies) for licence holders to abstract, and any abstractions that do occur reduce the amount of surface water available – affecting the wetted perimeter of the habitat, velocities within the wetted area and the ability to dilute any pollutants entering the system. For surface water abstractions, this includes consumptive abstraction and partially consumptive/non-consumptive abstraction – where some or all of the water is returned to the river locally after use, with the potential to reduce flow in the river if the discharge is downstream of the abstraction.

Definition of Risk

Continuously flowing watercourses

In order to define the potential risk to flow from river and groundwater abstractions in a readily understandable manner, a series of criteria have been defined. The assessment is informed by long term gauged flow data. The impact of the drought option will be considered against baseline 'drought' conditions (without drought option implementation). The assessment will use the following criteria, based on the potential severity of the risk to river water quality and flow during an ongoing drought.

- High: A major reduction in low river flows, including the influence of the drought option - typically >25% reduction in summer Q95 (with drought option in place)
- Medium: A moderate risk to low river flows (as above) , including the influence of the drought option - typically 10-25% reduction in summer Q95 (with drought option in place)
- Low: A minor risk to low river flows, including the influence of the drought option - typically <10% reduction in summer Q95 (with drought option in place)
- Negligible: Indicative of no significant change from the "without drought" option baseline situation.

Ephemeral watercourses

In line with the methodology for hydrology, an alternative approach to risk is required for

watercourses that naturally dry for part of the year that are potentially impacted upon by the drought option. Such watercourses are identified from previous investigations and available data. The assessment will use the following criteria, based on the potential severity of the risk to river water quality and flow during an ongoing drought.

- High: If the abstraction resulted in sections drying (with drought option in place) that would not (without drought option in place)
- Medium: If the abstraction resulted in sections drying earlier (by more than a handful of days) and/or returning to flow later (by more than a handful of days) and hence flow reduction occurring in the channel for more than just a handful of days (with drought option in place)
- Low: If the abstraction resulted in sections drying earlier (by just a handful of days) and/or returning to flow later (by just a handful of days) and hence flow reduction occurring in the channel for more than just a handful of days OR if the abstraction were a secondary flow driver (e.g. flow through gravels being primary cause of flow losses rather than the drought permit) (with abstraction in place)
- Negligible: Indicative of no significant change from the "without drought" option baseline situation.

Data Requirements

- Relevant zone of influence (as identified from screening)
- Surface water and groundwater abstraction licences in the zone of influence
- River flow representative of the zone of influence (daily gauged flow and spot flow surveys) – all available records
- Flow predictions and zones of hydrological impact for each drought option.

Assessment Methodology and Uncertainty

1. Identify relevant abstraction licences within the zone of hydrological impact for the drought option: both groundwater abstractions from the aquifer(s) impacted by the drought option (confined and unconfined) and surface water abstractions from the impacted river reaches.

Groundwater abstractions

2. For groundwater abstractions, identify which aquifer they abstract from and key characteristics of the aquifer (confined/unconfined) if available. List relevant details from each abstraction licence including licence number, holder, use, depth abstracted from and maximum daily abstraction rate.
3. Use depths of abstraction to identify which of these abstractions are likely to be affected by reduced groundwater levels in the aquifer with the drought option in place. If depth information is not available, take a precautionary approach and assume all abstractions within the relevant area (or, if known, from the relevant aquifer) are affected.
4. Calculate the maximum volume of groundwater abstractions from each aquifer at low flows (i.e. the sum of abstractions of sufficient depth from the aquifer) with a drought option in place.

5. Use expert judgement to assess the in-combination significance of these groundwater abstractions on river flows in impacted reaches (both continuously flowing and ephemeral watercourses), based on known (measured or modelled) relationships between groundwater levels and river flows in that area and the definition of risk set out above.

Surface water abstractions – continuously flowing watercourses

6. Assign relevant abstraction licences to an impacted river reach, and list relevant details from the licence including licence number, holder, use, type (consumptive or non-consumptive), location (mainstem or tributary) and daily maximum abstraction rate (including any Hands-Off Flow restrictions). Identify which of these abstractions are likely to be affected by reduced water levels in the river with the drought option in place.
7. Calculate the maximum volume of surface water abstractions in each reach at low flows (i.e. the sum of consumptive, unrestricted abstractions on the main stem of the river) as a proportion of summer Q95 river flow with a drought option in place.
8. Assess the in-combination significance of these pressures on river flow with respect to hydrological assessment methodologies described in Section 2.2.2 of the main report.
9. Use expert judgement to assess the significance of these pressures on river flows based on the definition of risk set out above.

Surface water abstractions – ephemeral watercourses

10. Assign relevant abstraction licences to an impacted river reach, and list relevant details from the licence including licence number, holder, use, type (consumptive or non-consumptive), location (mainstem or tributary) and daily abstraction maximum (including any Hands-Off Flow restrictions). Identify which of these abstractions are likely to be affected by reduced water levels in the river with the drought option in place.
11. Use expert judgement to assess the significance of these pressures on river flows based on the definition of risk set out above.

All abstractions

12. For both groundwater and surface water abstractions, incorporate any flow pressure risks identified as significant into the assessment of impacts on significant features and the selection of appropriate mitigation measures for the drought option.

WATER QUALITY PRESSURES

Potential Effects

In support of the physical environment understanding and risk assessment in the zone of influence of each drought option, a review will be undertaken of additional water quality pressures from consented surface water discharges. Discharges put pressure on water quality during a drought as lower than normal river flows mean that there is less water available to dilute discharges such as final effluent from STW. A drought option may exacerbate these low flows and contribute to a reduction in water quality, with potentially detrimental impacts on sensitive features in the impacted reach. Discharges impacting the oxygen balance and ammonia concentration (to support fish and macroinvertebrates, where these are identified as sensitive features) and soluble reactive phosphorus (SRP) concentration (to support macrophytes and algae, where these are identified as sensitive features) in the river have been reviewed.

Intermittent discharges from combined sewer overflows (CSOs) may also contribute to a reduction in water quality during an environmental drought. CSOs relieve strain on the sewers during storm events by temporarily diverting water into nearby watercourses to prevent sewer flooding. As there is usually a time lag between discharges from CSOs and rises in river levels during a storm event, the potential exacerbation of low flows by the drought option may decrease the amount of water immediately available to dilute CSO discharges, leading to a temporary reduction in river water quality if a storm event occurs during implementation of the drought option.

Definition of Risk

Continuously flowing watercourses

In order to define the potential risk to water quality from discharges into the river in a readily understandable manner, a series of criteria have been defined. The assessment will use the following criteria, based on the potential severity of the risk to water quality during an ongoing drought.

- High: A major risk to water quality under low river flow conditions (without the drought option) which affects the suitability of the water quality to support *Good* or *High* status for fisheries and macroinvertebrates, macrophytes and algae (as relevant); and exacerbation of the risk by the flow reduction from the drought option
- Medium: A moderate risk to water quality under low river flow conditions (without the drought option) which affects the suitability of the water quality to support *Good* or *High* status for fisheries and macroinvertebrates, macrophytes and algae (as relevant); or exacerbation of a minor risk by the flow reduction from the drought option
- Low: A minor risk to water quality under low river flow conditions (without the drought option) which affects the suitability of the water quality to support *Good* or *High* status for fisheries and macroinvertebrates, macrophytes and algae (as relevant); or exacerbation to a minor risk by the flow reduction from the drought option
- Negligible: Indicative of no significant risk without the drought option nor exacerbation of risk by the flow reduction from the drought option

Ephemeral watercourses

In line with the methodology for hydrology, an alternative approach to risk is required for

watercourses that naturally dry for part of the year that are potentially impacted upon by the drought option. Such watercourses are identified from previous investigations and available data. The assessment will use the following criteria, based on the potential severity of the risk to river water quality during an ongoing drought.

- High: A major risk to water quality under low river flow conditions (without the drought option) which affects the suitability of the water quality to support *Good* or *High* status for fisheries and macroinvertebrates, macrophytes and algae (as relevant); and exacerbation of the risk if the drought option resulted in sections drying (with drought option in place) that would not (without drought option in place)
- Medium: A moderate risk to water quality under low river flow conditions (without the drought option) which affects the suitability of the water quality to support *Good* or *High* status for fisheries and macroinvertebrates, macrophytes and algae (as relevant); or exacerbation of a minor risk by the flow reduction from the drought option occurring in the channel for more than just a handful of days.
- Low: A minor risk to water quality under low river flow conditions (without the drought option) which affects the suitability of the water quality to support *Good* or *High* status for fisheries and macroinvertebrates, macrophytes and algae (as relevant); or exacerbation to a minor risk by the flow reduction from the drought option occurring in the channel for just a handful of days.
- Negligible: Indicative of no significant risk without the drought option nor exacerbation of risk by the flow reduction from the drought option

Data Requirements

- Relevant zone of influence (as identified from screening)
- Surface water discharge consents in the zone of influence (including numeric water quality and flow conditions)
- Routine NRW / Environment Agency riverine water quality monitoring data for the water quality determinands dissolved oxygen saturation, SRP concentration and total ammonia concentration for relevant monitoring sites in the zone of influence and significant tributaries
- River flow representative of the zone of influence (daily gauged flow and spot flow surveys) – all available records
- Flow predictions and zones of hydrological impact for each drought option
- CSO locations and previous assessments of intermittent discharges from Welsh Water.

Assessment Methodology and Uncertainty

1. Identify sensitive features (fish, macroinvertebrates, macrophytes and algae) which may be impacted by the drought option. Use this information to determine whether assessment of oxygen balance, ammonia concentration and/or SRP concentration is required.
2. Identify all discharge consents within the zone of hydrological impact for the drought option.
3. Assign relevant discharge consents to an impacted reach, and list relevant details from the consent including consent number, holder, use, location (mainstem or tributary) and relevant numeric

consent conditions (Dry Weather Flow, BOD, ammonia (N), total phosphorous)[1].

4. Identify those discharge consents which relate to effluent from Welsh Water's sewage treatment works (STWs).

Continuously flowing watercourses

5. Model the maximum current contribution of each STW to BOD, ammonia (N) and total phosphorous concentrations (as relevant) in the river at low flows (based on the water quality consents, DWF and upstream flows).
6. Model the maximum potential increase in each STW's contribution to river BOD, ammonia (N) and total phosphorous concentrations (as relevant) at low flows as a result of the drought option (based on the water quality consents, DWF, upstream flows and maximum flow reduction from drought option).
7. Assess the potential risk that the STW could pose to river ammonia quality (using the consented discharge condition total ammonia) using modelled data and the appropriate matrix below. This combines an acknowledgement of existing conditions and potential variation as a result of the drought option.

Upland low alkalinity river		% increase in contribution as result of drought option(s)	
		<20%	≥20%
Current contribution to ammonia concentrations at low flows [a]	<0.2mgN/l	Minor	Moderate
	≥0.2mgN/l	Moderate	Major

[a] Standards are WFD high/good threshold for ammonia (N) of 0.2mg/l for upland low alkalinity rivers[2].

Lowland high alkalinity river		% increase in contribution as result of drought option(s)	
		<20%	≥20%
Current contribution to ammonia concentrations at low flows [b]	<0.3mgN/l	Minor	Moderate
	≥0.3mgN/l	Moderate	Major

[b] Standards are WFD high/good threshold for ammonia (N) of 0.3mg/l for lowland high alkalinity rivers[3].

8. Assess the potential risk that the STW could pose to river oxygen balance (using the consented discharge condition BOD) using modelled data and the matrix below. This combines an acknowledgement of existing conditions and potential variation as a result of the drought option.

Upland low alkalinity river		% increase in contribution as result of drought option(s)	
		<20%	≥20%
Current contribution to BOD concentrations at low flows [c]	<1mg/l	Minor	Minor
	1-3mg/	Minor	Moderate
	≥3mg/l	Moderate	Major

[c] Standards are WFD high/good threshold for BOD of 3mg/l and good/moderate threshold of 4mg/l for upland low alkalinity rivers[4].

Lowland high alkalinity river		% increase in contribution as result of drought option(s)	
		<20%	≥20%
Current contribution to BOD concentrations at low flows [d]	<1mg/l	Minor	Minor
	1-4mg/	Minor	Moderate
	≥4mg/l	Moderate	Major

[d] Standards are WFD high/good threshold for BOD of 4mg/l and good/moderate threshold of 5mg/l for lowland high

[1] Note that not all STWs have water quality consents relating to ammonia or total phosphorous (depends on size and location of STW). Consents are set with respect to total phosphorous rather than SRP.

[2] The River Basin Districts Typology, Standards and Groundwater threshold values (Water Framework Directive) (England and Wales) Directions 2010. ISBN 978-0-85521-192-9.

[3] The River Basin Districts Typology, Standards and Groundwater threshold values (Water Framework Directive) (England and Wales) Directions 2010. ISBN 978-0-85521-192-9.

[4] The River Basin Districts Typology, Standards and Groundwater threshold values (Water Framework Directive) (England and Wales) Directions 2010. ISBN 978-0-85521-192-9.

alkalinity rivers[5].

9. Assess the potential risk that the STW could pose to river phosphorous quality (using the consented discharge condition total phosphorous) using modelled data and the matrix below. This combines an acknowledgement of existing conditions and potential variation as a result of the drought option. Consents are set with respect to total phosphorous rather than SRP (on which WFD river standards are based), therefore this approach conservatively assumes that all phosphorous from STWs is reactive and has direct implications for ecology in the river.

Upland low alkalinity river		% increase in contribution as result of drought option(s)	
		<20%	≥20%
Current contribution to ammonia concentrations at low flows [e]	<0.2mgN/l	Minor	Moderate
	≥0.2mgN/l	Moderate	Major

[e] Standards are WFD high/good threshold for SRP of 0.02mg/l and good/moderate threshold of 0.04mg/l for upland low alkalinity rivers[6].

Lowland low alkalinity river[7]		% increase in contribution as result of drought option(s)	
		<20%	≥20%
Current contribution to ammonia concentrations at low flows [f]	<0.03mgN/l	Minor	Moderate
	≥0.03mgN/l	Moderate	Major

[f] Standards are WFD high/good threshold for SRP of 0.03mg/l and good/moderate threshold of 0.05mg/l for lowland low alkalinity rivers[8].

Upland/ lowland high alkalinity river		% increase in contribution as result of drought option(s)	
		<20%	≥20%
Current contribution to ammonia concentrations at low flows [g]	<0.05mgP/l	Minor	Moderate
	≥0.05mgP/l	Moderate	Major

[g] Standards are WFD high/good threshold for SRP of 0.05mg/l and good/moderate threshold of 0.12mg/l for upland/ lowland high alkalinity rivers[9].

10. Identify those discharges which relate to effluent from Welsh Water's combined sewer overflows (CSOs).
11. If required, carry out qualitative analysis using previous assessments of intermittent discharges to evaluate whether any CSOs are likely to present a significant water quality pressure as a result of the drought option.
12. Use expert judgement to assess the significance of these pressures on river flows based on the definition of risk set out above.
13. Incorporate any water quality pressure risks identified as significant into the assessment of impacts on significant features and the selection of appropriate mitigation measures for the drought option.

Ephemeral watercourses

14. Calculate the maximum concentrations of BOD, ammonia (N) and SRP (as relevant) in the final effluent of each STW under consented conditions (i.e. concentrations in the river with no natural dilution).

[5] The River Basin Districts Typology, Standards and Groundwater threshold values (Water Framework Directive) (England and Wales) Directions 2010. ISBN 978-0-85521-192-9.

[6] The River Basin Districts Typology, Standards and Groundwater threshold values (Water Framework Directive) (England and Wales) Directions 2010. ISBN 978-0-85521-192-9.

[7] Note that "Lowland low alkalinity" is a category that only exisits for SRP standards, and not for total ammonia or BOD.

[8] The River Basin Districts Typology, Standards and Groundwater threshold values (Water Framework Directive) (England and Wales) Directions 2010. ISBN 978-0-85521-192-9.

[9] The River Basin Districts Typology, Standards and Groundwater threshold values (Water Framework Directive) (England and Wales) Directions 2010. ISBN 978-0-85521-192-9.

15. Identify those discharges which relate to effluent from Welsh Water's combined sewer overflows (CSOs).
16. If required, carry out qualitative analysis using previous assessments of intermittent discharges to evaluate whether any CSOs are likely to present a significant water quality pressure as a result of the drought option.
17. Use expert judgement to assess the significance of these pressures on river flows based on the definition of risk set out above.
18. Incorporate any water quality pressure risks identified as significant into the assessment of impacts on significant features and the selection of appropriate mitigation measures for the drought option.

WATER FRAMEWORK DIRECTIVE STATUS: FISH

Potential Effects
For WFD river waterbodies within the zone of influence of the drought option, where screening of the drought option has identified that the fish element of biological status is *High* or *Good*, the potential impact is to be investigated. This investigation is specific to the risk of deterioration below the *Good* status band to the *Moderate* status band, as advised by NRW / Environment Agency.
Definition of Impacts
In order to define the potential WFD status impacts for fish in a readily understandable manner, a series of criteria have been defined. The assessment will use the following criteria, based on the potential severity of the drought option impacts during an ongoing drought. • Major: A major impact is one that results in deterioration in the WFD classification of the waterbody, or specifically the fish biological element of the classification. • Moderate: A moderate impact on fish status occurs when the fish population is predicted to be materially influenced, including effects on density, abundance or community composition, but where no deterioration in WFD classification is predicted. Consideration should be given to the scale of the impact and the potential for recovery of the populations. • Minor: A minor impact occurs when there is a predicted impact on fish abundance, density or community composition that is within the usual variability for the site and which will recover within a short timescale. • Negligible: A negligible impact is one where the predicted impact will not result in a detectable change in the fish population.
Data Requirements
Fish status baseline assessment requires data from standard NRW / Environment Agency monitoring programmes in the potentially impacted zone, and preferably in a control site outside of the zone of influence. Fish data should include species presence, abundance and density. Environmental supporting data should include habitat availability, hydrology (flow, velocity, wetted area (width and depth) as follows: • Relevant study area (as identified in the screening report) • Hydrology at or close to the monitoring sites to link to fish data, including full flow hydrograph, wetted width and depth, velocity profile. Will include daily gauged flow and spot flow surveys, all available records • Meteorology (where flow data insufficient) from available NRW / Environment Agency rain gauges • Habitat data for the monitoring sites, which may include recent RHS or Habscore surveys • Routine NRW / Environment Agency water quality monitoring data (dissolved oxygen, BOD, ammonia, pH, hardness, water temperature, conductivity) representative of the study area.

Assessment Methodology and Uncertainty
The WFD classification for the waterbody will be identified and the reasons for classification established from the NRW / Environment Agency. The data used to support the assessment will be reviewed to ensure that the classification is accurate. Baseline conditions for sites within the zone of influence of the drought option will be established through existing data. These will include graphing the hydrology, water quality, habitat and fish variation temporally over the monitored period. The analysis will consider the relationship between fish status and the supporting environmental variables over the period, with an emphasis on changes to fish status and environmental conditions between low, average and high flow years. The purpose of the analysis is to establish whether fish status responds to changes in flow and associated environmental variables inter-annually relating to changes in flow, climate, quality (dissolved oxygen and temperature) and/or habitat quality and availability. Having established the baseline conditions and variability outside the drought option conditions (care will be taken to avoid using periods in the baseline analysis within which a drought option may have been in operation), a prediction will be made of the changes in the supporting environmental variables (flow, habitat and water quality) resulting from application of the drought option. This will be undertaken for the hydrological data by overlaying the drought option flows over the baseline flow hydrograph, and, where cross sectional data are available, how the wetted width and depth will vary with the drought option. This can be extrapolated to the habitat data to consider whether the key features are compromised by the change in water depth. Once the flow, habitat and water quality drought option predictions have been established, their implications for existing fish species will be assessed. The flow and habitat environmental envelope of the key fish species is known. The predicted changes in supporting environmental variables (flow, depth, velocity, habitat quality, dissolved oxygen levels and temperature) due to the drought option will be assessed against the fish population data. Where the supporting environmental variables for fish species are modified to take them outside of their preferred envelope it can be assumed that there will be a moderate or major impact on that fish population. Consideration will be given to the potential for density dependent mortality where data show that the fish population has an existing good density, and where the drought option reduces habitat availability significantly The assessment will consider the scale and longevity of any fish status impacts. The WFD classification is calculated on a 3 year rolling basis. A deterioration in classification would require a long term (2+ breeding seasons) and significant effect on fish population structure to allow prediction of a deterioration in status. Where data are not available the assessment will be undertaken using expert judgement and drawing on broad-scale evidence from other similar catchments if applicable. The prediction of impacts of hydrological and water quality changes on aquatic ecology remains subject to significant uncertainty. This is exacerbated where few data or

surveillance data are used for impact assessment purposes. Lastly the environmental envelopes within which fish species can successfully exist, and the relationship between populations in stressed river conditions remains subject to debate. The assessment must therefore be undertaken in recognition that the outcome prediction will be subject to large potential variability. The study will therefore adopt a precautionary approach, with potential impact highlighted where doubt exists. Monitoring and mitigation proposals for the drought option can then be specified so that, should an option be enacted, the actual impact can be recorded and adaptive mitigation/management of the option undertaken to safeguard where possible the fish populations.

WATER FRAMEWORK DIRECTIVE STATUS: MACROINVERTEBRATES

Potential Effects

For Water Framework Directive (WFD) river waterbodies within the zone of influence of the drought option, where screening of the drought option has identified that the aquatic macroinvertebrate component of ecological status is *High* or *Good*, the potential impact is to be investigated. This investigation is specific to the risk of deterioration below the *Good* status band to the *Moderate* status band.

Definition of Impacts

In order to define the potential WFD status impacts for aquatic macroinvertebrates in a readily understandable manner, a series of criteria have been defined. The assessment will use the following criteria, based on the potential severity of the drought option impacts during an ongoing drought.

- Major: A major impact is one that results in deterioration in the WFD classification of the waterbody, or specifically the macroinvertebrate biological element of the classification.
- Moderate: A moderate impact on macroinvertebrate status occurs when the macroinvertebrate community is predicted to be materially influenced, including reduction in the LIFE score, or in community density +/or abundance, but where no deterioration in WFD classification is predicted. Consideration should be given to the scale of the impact and the potential for recovery of the community.
- Minor: A minor impact occurs when there is a predicted impact on macroinvertebrate abundance, density or composition that is within the usual variability for the site and which will recover within a short timescale.
- Negligible: A negligible impact is one where the predicted impact will not result in a detectable change in the macroinvertebrate community.

Data Requirements

The baseline for macroinvertebrates will be established from existing data together with a comparison of species flow preference and taxon abundance. The analysis will provide an assessment of the community type and its sensitivity.

Macroinvertebrate status baseline assessment requires data from standard NRW / Environment Agency monitoring programmes in the potentially impacted zone, and preferably in a control site outside of the zone of influence. Macroinvertebrate data should include the LIFE and BMWP scores, together with abundance and density data where available. Environmental supporting data should include habitat availability, hydrology (flow, velocity, wetted area (width and depth) and other environmental variables as follows:

- Relevant study area (as identified by screening)
- Hydrology at or close to the monitoring sites to link to macroinvertebrate data, including full flow hydrograph, wetted width and depth, velocity profile. Will include daily gauged flow and spot flow surveys, all available records
- Meteorology (where flow data insufficient) from available NRW / Environment Agency

rain gauges

- Habitat data for the monitoring sites, which may include recent RHS or Habscore surveys, to calculate HQA / HMS.
- Routine NRW / Environment Agency water quality monitoring data (dissolved oxygen, BOD, ammonia, pH, hardness, water temperature, conductivity) representative of the study area.

Assessment Methodology and Uncertainty

Having established the baseline, the relative changes expected as a result of the drought actions (in relation to normal drought conditions) in river hydrology, geomorphology and water quality will be identified (see WFD fish assessment). An assessment will then been made of the habitat requirements of the key riverine macroinvertebrate communities present, using existing knowledge of their range of preferences. Depending on the resolution of baseline data available, detailed statistical analysis of the datasets may be possible. However, in some cases, where relatively limited spatial and/or temporal datasets are available, the impact assessment of the drought actions will be based on qualified expert judgement of the potential effects of the predicted changes in the environmental variables on the macroinvertebrate communities. The analysis is supplemented by consideration of the implications of environmental change on the key macroinvertebrate metrics, including LIFE scores.

The WFD macroinvertebrate classification for the water body will be identified and the reasons for classification established from the NRW / Environment Agency. The data used to support the assessment will be analysed to ensure that the classification is accurate.

Baseline conditions for sites within the zone of influence of the drought option will be established through existing data. These will include graphing the hydrology, water quality, and macroinvertebrate (ASPT and LIFE scores) variation temporally over the monitored period.

The analysis will consider the relationship between macroinvertebrate status and the supporting environmental variables over the period, with an emphasis on changes to status and environmental conditions between low, average and high flow years. The purpose of the analysis is to establish whether status responds to changes in flow and associated environmental variables inter-annually relating to changes in flow, climate, quality (dissolved oxygen and temperature) and/or habitat quality and availability.

Having established the baseline conditions and variability outside the drought option conditions (care will be taken to avoid using periods in the baseline analysis within which a drought option may have been in operation), a prediction will be made of the changes in the supporting environmental variables (flow, habitat and water quality) resulting from application of the drought option. This will be undertaken for the hydrological data by overlaying the drought option flows over the baseline flow hydrograph, and, where cross sectional data are available, how the wetted width and depth will vary with the drought option. This can be extrapolated to the habitat data to consider whether the key features are compromised by the change in water depth. These data may have been developed for the WFD fish status assessment and duplication of effort will be avoided.

Once the flow, habitat and water quality drought option predictions have been established, their implications for the existing macroinvertebrate community will be assessed. The linkage between flow and habitat environmental envelope for upland macroinvertebrate communities is subject to continuing debate but has been shown to be linked (see for example, Dunbar et al 2009; 2010). The predicted changes in supporting environmental variables (flow, habitat quality) due to the drought option should be assessed against the macroinvertebrate community LIFE scores. Consideration will be given to the relationships between flow, habitat and LIFE scores in the DRIED-UP research papers. The predicted relative change in Q_{95} low flow value for the drought option should be compared to the Q_{95}/reduction in LIFE score; HQA/reduction in LIFE score in Dunbar *et al* 2010 to develop an approximation of the scale of change in macroinvertebrate community that could be expected.

The assessment will consider the scale and longevity of any macroinvertebrate community impacts. The WFD classification is calculated on a 3 year rolling basis. A deterioration in classification would require a long term and significant effect on macroinvertebrate community structure to establish prediction of a deterioration in status.

Where data are not available the assessment will be undertaken using expert judgement and drawing on broad-scale evidence from other similar catchments within the reservoir group.

The prediction of impacts of hydrological and water quality changes on aquatic ecology remains subject to significant uncertainty. This is exacerbated where few data or surveillance data are used for impact assessment purposes. Lastly the environmental envelopes within which the macroinvertebrate community can successfully exist, and the relationship between populations in stressed river conditions remains subject to debate. For macroinvertebrates the evidence base for the prediction of flows and changes to LIFE score remain subject to significant debate. The assessment must therefore be undertaken in recognition that the outcome prediction will be subject to large potential variability. The study should therefore adopt a precautionary approach, with potential impact highlighted where doubt exists. Monitoring and mitigation proposals for the drought option can then be specified so that, should an option be enacted, the actual impact can be recorded and adaptive mitigation/management of the option undertaken to safeguard where possible the macroinvertebrate community.

NOTABLE SPECIES, DESIGNATED SITES AND OTHER SENSITIVE FAUNA AND FLORA

Potential Effects

Where screening of the drought option has identified that a notable species or designated site is present within the zone of influence of the drought option and screening has indicated that it is sensitive to the impacts of the drought option, the potential impact is to be investigated. Notable species are defined as Environment (Wales) Act Section 7 species or species with significant ecological sensitivity in the specified locality including species listed on IUCN red list and those not included in the red list which are nonetheless uncommon. This investigation will consider the habitat preferences of the species and its lifestages (if appropriate) and the impacts of the variation in flow (and consequent physical habitat and ecosystem) on these preferences. Potential effects are associated either 1) directly to a reduction in river flow; or 2) a reduction in water quality; 3) secondary effects of reduced velocity, for example on sediment characteristics.

Definition of Impacts

In order to define the potential impacts for sensitive ecological features in a readily understandable manner, a series of criteria have been defined. The significance of impacts upon the sensitive ecological feature will be identified following the Institute of Ecology and Environmental Managements (CIEEM) Ecological Impact Assessment (EcIA) guidance[10]. The potential significance of the impacts is identified using the following:

- **Value of the Ecological Receptor** – each ecological receptor is attributed a geographic value based upon its legislative and conservation status, as identified in Table 1.

Table 1 Value of Ecological Receptor

Ecological Value	Example
International	Existing or warranting designation as a e.g SPA and/or of significant conservation status for Europe (e.g European Protected Species (EPS)).
National	Existing or warranting designation as a SSSI and/or of significant conservation status for England (i.e. identified as a NERC / Environment Act (Wales) Section 7 species).
Regional	Habitats or species valuable at a regional level and/or of significant conservation status for the region (e.g viable breeding populations of Nationally Scarce species).
County	For example, existing or warranting designation as a County Wildlife Site (CWS) and/or of significant conservation status for the county (e.g viable breeding populations of species of county/metropolitan rarities).
District	For example, habitats or species of significant conservation status for the district (e.g viable breeding populations of species listed as rare in the district or borough).
Parish (local)	Species whose presence is considered to appreciably enrich biodiversity within the context of the parish or local neighbourhood, including as a local recreational/educational resource.
Site (within zone of influence only)	Species which are so low grade or widespread so as to be considered as not contributing to biodiversity value outside the boundaries of the site.

- **Positive or Negative Impact** – all impacts are considered to be negative unless

[10] CIEEM (2018) *Guidelines for Ecological Impact Assessment in the UK and Ireland: Terrestrial, Freshwater, Coastal and Marine.* Chartered Institute of Ecology and Environmental Management, Winchester.

otherwise stated in the feature assessment.

- **Extent** – the extent of the impact is covered as part of the magnitude consideration.
- **Magnitude** – the magnitude of the impact is identified using the criteria identified in **Table 2**

Table 2 Magnitude of Impact

Impact Magnitude	Description
High	There is a long-term large-scale (i.e. catchment) change in the ecological receptor and/or changes in the overall integrity of the ecological receptor.
Medium	There is a short-term large-scale change or long-term short-scale (i.e. reach) change in the ecological receptor, however no changes in the overall integrity of the ecological receptor.
Low	There is a short-term small-scale change in the ecological receptor, but its overall integrity is not impacted.
Negligible	No perceptible change in the ecological receptor.

- **Duration** – the duration of impact is considered to be for 6 months, which is the duration for which a drought option is implemented, unless otherwise stated.
- **Reversibility** – all impacts are considered to be reversible unless they are identified to have a likely impact upon the overall integrity of the ecological receptor.
- **Timing and Frequency** – the drought option could be implemented at any point in the year, however the different life stages of the sensitive ecological features will be taken into account. The assessment is based upon the operation of a single drought permit, with subsequent applications for a drought permit required to consider cumulative effects of multiple drought permits.
- **Probability** – all impacts are considered to be probable, unless otherwise stated.

Once the value of the ecological receptor, magnitude of impacts and other parameters listed above have been identified, these are used to inform the assessment of significance of impact on the ecological receptor.

Data Requirements

Sensitive ecological features baseline review requires data from standard NRW / Environment Agency monitoring programmes in the potentially impacted zone, and preferably in a control site outside of the zone of influence. Data should include species presence, abundance and density. It is likely that most fisheries data will be for O and O+ lifestages, with some indication of older echelons. Environmental supporting data should include habitat availability, hydrology and water quality as follows:

- Relevant study area (as identified in the screening report)
- Hydrology at or close to the monitoring sites to link to fish data, including full flow hydrograph, wetted width and depth, velocity profile. Will include daily gauged flow and spot flow surveys, all available records

- Meteorology (where flow data insufficient) from available NRW / Environment Agency rain gauges
- Habitat data for the monitoring sites, which may include recent RHS or Habscore surveys
- Routine NRW / Environment Agency water quality monitoring data (dissolved oxygen, BOD, ammonia, pH, hardness, water temperature, conductivity) representative of the study area
- Habitat preferences for the given sensitive ecological features will be described, against which habitat change can be assessed.

Assessment Methodology and Uncertainty

The NERC / Environment (Wales) Act Section 7 species status for the watercourses will be identified and the reasons for its inclusion in the NERC / Environment (Wales) Act Section 7 established from the relevant bodies (start with NRW / Environment Agency). The data used to support the Environment (Wales) Act Section 7 assessment will be reviewed to ensure that it is accurate.

Baseline conditions for sites within the zone of influence of the drought option will be established through existing data. These should include graphing the hydrology, water quality, habitat and fish variation temporally and, if multiple sites, spatially over the monitored period. The analysis will consider the relationship between sensitive ecological feature lifestages and the supporting environmental variables over the period, with an emphasis on changes to status and environmental conditions between low, average and high flow years. The purpose of the analysis is to establish whether the sensitive ecological features population responds to changes in flow and associated environmental variables inter-annually relating to changes in flow, climate, quality (dissolved oxygen and temperature) and/or habitat quality and availability.

Having established the baseline conditions and variability outside the drought option conditions (care will be taken to avoid using periods in the baseline analysis within which a drought permit may have been in operation), a prediction will be made of the changes in the supporting environmental variables (flow, habitat and water quality) resulting from application of the drought option conditions. Ideally this will be undertaken for the hydrological data by overlaying the drought option flows over the baseline flow hydrograph, and, where cross sectional data are available, how the wetted width and depth will vary with the drought option. This can be extrapolated to the habitat data to consider whether the key features are compromised by the change in water depth. In many cases these data are currently unlikely to exist and proxy measures such as RHS and/or aerial survey data will be used.

Once the flow, habitat and water quality drought option predictions have been established, their implications for the sensitive ecological features will be assessed. The flow and habitat environmental preferences of the sensitive ecological features will be described. The predicted changes in supporting environmental variables (flow, depth, velocity, habitat quality, dissolved oxygen levels and/or temperature) due to the drought option should be assessed against the sensitive ecological features population data.

Where data are not available the assessment will be undertaken using expert judgement and

drawing on broad-scale evidence from other similar catchments.

The prediction of impacts of hydrological and water quality changes on aquatic ecology remains subject to significant uncertainty. This is exacerbated where few data or surveillance data are used for impact assessment purposes. Lastly the environmental preferences within which species can successfully exist, and the relationship between populations in stressed river conditions remains subject to debate. The assessment must therefore be undertaken in recognition that the outcome prediction will be subject to large potential variability. The study will therefore adopt a precautionary approach, with potential impacts highlighted where doubt exists. Monitoring and mitigation proposals for the drought option can then be specified so that, the actual impact can be recorded and adaptive mitigation/management of the option undertaken to safeguard where possible the sensitive ecological features populations.

Habitat Preferences

Habitat Preferences		**Unfavourable Habitat**	**Potential Impacts**
Type/ Age Class	**Description**		
Atlantic salmon *Salmo salar* and Brown/Sea trout *Salmo trutta*			
Spawning	• Clean and unconsolidated gravels typically in the transitional area between pools and riffles where the flow is accelerating and depth is decreasing	-	Deposition of silt
			Reduction in velocity, depth and/or wetted width, possibly resulting in exposure of river bed
			Increased water velocity and depth
Nursery (fry and parr life stage)	• Shallow areas with a low water velocity and pebble substrate, often at the margins of riffles	• Deep and/or high velocity habitats.	Reduction in velocity, depth and/or wetted width, possibly resulting in exposure of river bed
			Increased water velocity and depth
			Increased risk of entrainment into water intake
			Deterioration in water quality
Adults	Deep habitats that provide shelter including one or more of the following: • submerged structures • undercut banks • overhanging vegetation < 50cm above the water surface • water surface turbulence causing a broken surface • Deep pools downstream of obstacles and sufficient water quantity through structures to enable passage across obstacles.	• Open and shallow habitats, but will use these during migration to reach spawning gravels. • Habitats upstream of significant obstructions.	Reduction in velocity, depth and/or wetted width, possibly resulting in exposure of river bed
			Increased water velocity and depth
			Increased risk of entrainment into water intake
			Increased significance of barriers to impede migration as a result of decreased flows
			Deterioration in water quality
Brook lamprey *Lampetra planeri*			
Spawning	• Clean, unconsolidated spawning gravels with suitable sheltering areas, usually located at the tail end of pools where flows are increasing.	- -	Deposition of silt
			Reduction in velocity, depth or wetted width resulting in exposure of river bed
			Increased water velocity and depth
Nursery	• Areas of sandy silt with slow water velocity, often in the margins of watercourses, above the estuary. • Variation in depth between 2 cm and 30 cm (>15cm is optimal) with a relatively high organic content.		Reduction in velocity, depth and/or wetted width, possibly resulting in exposure of river bed
			Increased water velocity and depth
			Increased risk of entrainment into water intake

Habitat Preferences		Unfavourable Habitat	Potential Impacts
Type/ Age Class	**Description**		
			Deterioration in water quality
Adults	• Cover (stones and vegetation) in the vicinity of spawning gravels.		Reduction in velocity, depth and/or wetted width, possibly resulting in exposure of river bed
			Increased water velocity and depth
			Increased risk of entrainment into water intake
			Deterioration in water quality
River lamprey *Lampetra fluviatilis*			
Spawning	• Clean and unconsolidated spawning gravels with suitable sheltering areas, usually located at the tail end of pools where flows are increasing.	-	Deposition of silt
			Reduction in velocity, depth or wetted width resulting in exposure of river bed
			Increased water velocity and depth
Nursery	• Areas of sandy silt with slow water velocity, often in the margins of watercourses, above the estuary. Variation in depth between 2cm and 30cm (>15cm is optimal) with a relatively high organic content.	-	Reduction in velocity, depth or wetted width resulting in exposure of river bed
			Increased water velocity and depth
			Increased risk of entrainment into water intake
			Deterioration in water quality
Adults	• Suitable estuarine conditions, that is free from pollution and with suitable prey species available. • Clear migration routes from the estuary to spawning grounds with suitable river flows and no barriers.	• Areas with significant pollution or limited prey availability. • Habitats upstream of significant obstructions.	Increased significance of barriers to impede migration as a result of decreased flows
			Increased risk of entrainment into water intake
			Deterioration in water quality
Sea lamprey, *Petromyzon marinus*			
Spawning	• Clean and unconsolidated spawning gravels with suitable sheltering areas, usually located at the tail end of pools where flows are increasing.	-	Deposition of silt
			Reduction in velocity, depth or wetted width resulting in exposure of river bed
			Increased water velocity and depth
Nursery	• Areas of sandy silt with slow water velocity, often in the margins of watercourses, above the estuary. Variation in depth between 2cm and 30cm (>15cm is optimal) with a relatively high organic content.	-	Reduction in velocity, depth or wetted width resulting in exposure of river bed
			Increased water velocity and depth
			Increased risk of entrainment into water intake
			Deterioration in water quality
Adults	• Suitable estuarine conditions, that is free from pollution and with suitable prey species available. • Clear migration routes from the estuary to spawning grounds with suitable river flows and no barriers.	• Areas with significant pollution or limited prey availability. • Habitats upstream of significant obstructions.	Increased significance of barriers to impede migration as a result of decreased flows
			Increased risk of entrainment into water intake
			Deterioration in water quality
Bullhead, *Cottus gobio*			
Spawning	• Coarse, hard substrate of gravel and stones.	• Deep, silty watercourses with high flow velocities and little or no cover.	Deposition of silt
			Reduction in velocity, depth and/or wetted width
			Increased water velocity and depth

Habitat Preferences		Unfavourable Habitat	Potential Impacts
Type/ Age Class	**Description**		
Nursery	• Shallow, stony riffles		Reduction in velocity, depth and/or wetted width, possibly resulting in exposure of river bed
			Increased water velocity and depth
			Increased risk of entrainment into water intake
			Deterioration in water quality
Adult	• Sheltered sections created by woody debris, tree roots, leaf litter, macrophyte cover or larger stones.		Reduction in velocity, depth and/or wetted width, possibly resulting in exposure of river bed
			Increased water velocity and depth
			Increased risk of entrainment into water intake
			Deterioration in water quality
European eel, *Anguilla anguilla*			
Juvenile (<30cm)	• Wetland habitats within 30km of tidal limit with high diversity and cover of vegetation, soft substrates and high productivity.	• Low productivity watercourses with dominance of coarse substrates and low macrophyte cover and diversity. • Habitats upstream of significant obstructions.	Reduction in velocity, depth and/or wetted width, possibly resulting in exposure of river bed
			Increased water velocity and depth
			Increased risk of entrainment into water intake
			Deterioration in water quality
Adult (>30cm, female >45cm)	• Deep, slow flowing watercourses and wetland habitats within 80km of tidal limit with high diversity and cover of vegetation, soft substrates and high productivity.		Reduction in velocity, depth and/or wetted width, possibly resulting in exposure of river bed
			Increased significance of barriers to impede migration as a result of decreased flows
			Increased water velocity and depth
			Increased risk of entrainment into water intake
			Deterioration in water quality
Barbel *Barbus barbus*			
Spawning	• Run/glide flow • Less than 50cm deep • Velocities greater than 0.5m/s • Substrate composed of clean and uncompacted gravel	-	Deposition of silt
			Reduction in velocity, depth or wetted width resulting in exposure of river bed
			Increased water velocity and depth
Nursery	• Marginal shallow bays set back from or within margins of main channel • Depths between 1cm and 30cm • No discernible to minimal flow • Substrate composed of >30% gravel and sand with low silt content • Lack of or very little riparian shading		Reduction in velocity, depth and/or wetted width, possibly resulting in exposure of river bed
			Increased water velocity and depth
			Increased risk of entrainment into water intake
			Deterioration in water quality
Adults	• Commonly associated with stretches of clean gravel and macrophyte beds, showing a preference to relatively fast-flowing stretches in the middle reaches of large rivers. • The species also occupies deep water habitats at the foot of weirs,		Reduction in velocity, depth and/or wetted width, possibly resulting in exposure of river bed
			Impedance to movement upstream
			Increased water velocity and depth
			Increased risk of entrainment into water intake

Habitat Preferences		Unfavourable Habitat	Potential Impacts
Type/ Age Class	**Description**		
	in the lee of large woody debris, rock ledges or other obstructions on the river bed.		Deterioration in water quality Increased water velocity and depth
Fine-lined pea mussel, *Pisidium tenuilineatum* and depressed river mussel *Pseudanodonta complanata*			
All life stages	• Fine sediments of lowland rivers and canals,	• High velocity watercourses with coarse substrates.	Reduction in velocity, depth and/or wetted width, possibly resulting in exposure of river bed
White-clawed crayfish *Austropotamobius pallipes*			
All life stages	• Slow-flowing sections of stony rivers • Boulder riffles in chalk or clay streams • Submerged tree roots • Debris dams • Crevices in old or damaged submerged brickwork, stonework, cracked concrete or rotten wooden structures • Un-mortared stone revetting which protects banks from erosion • Stands of submerged and emergent aquatic plants • Old gravel workings and chalk pits • Good water quality	• Uniform clay channels • Areas of deep or soft silt • Dense filamentous algae • Narrow fast-flowing channels • Areas of sand and gravel, or bedrock, which are lacking in cobble or boulder (though they may feed in or commute through these areas) • Pebble or cobble shingle regularly exposed by changing river levels • Areas of armoured bed where the substrate is compacted by the river flow • Acidic streams or ochreous drainage • Poor water quality or salinity	Reduction in velocity, depth and/or wetted width, possibly resulting in exposure of river bed Increased water velocity and depth Increased risk of entrainment into water intake Transfer of non-native species or disease Deterioration in water quality

APPENDIX D
ENVIRONMENTAL FEATURES ASSESSMENT

D1 INTRODUCTION

This appendix presents information regarding the environmental features associated with the Llyn Bodlyn drought order. Baseline data and the impact assessments are presented for the environmental features that form part of the scope of the assessment (established by the screening exercise described in Section 3.2.2 of the EAR and results of which are summarised in Section 5.2). The features assessment presented in full below is summarised in Section 5.3 of the EAR.

Points of interest referred to throughout the text are indicated in **Figure D1.1**.

The approach to the assessment addresses the following: i) potential effects on each sensitive receptor; ii) definitions for impacts (adverse / beneficial), i.e. the significance criteria (quantitative and / or qualitative measures used to grade the severity of impacts of the drought order for the impact criteria major, moderate, minor, negligible; following the requirements of the DPG); iii) the data requirements; iv) assessment methodology (including the treatment of uncertainty where the complete data requirements are not available).

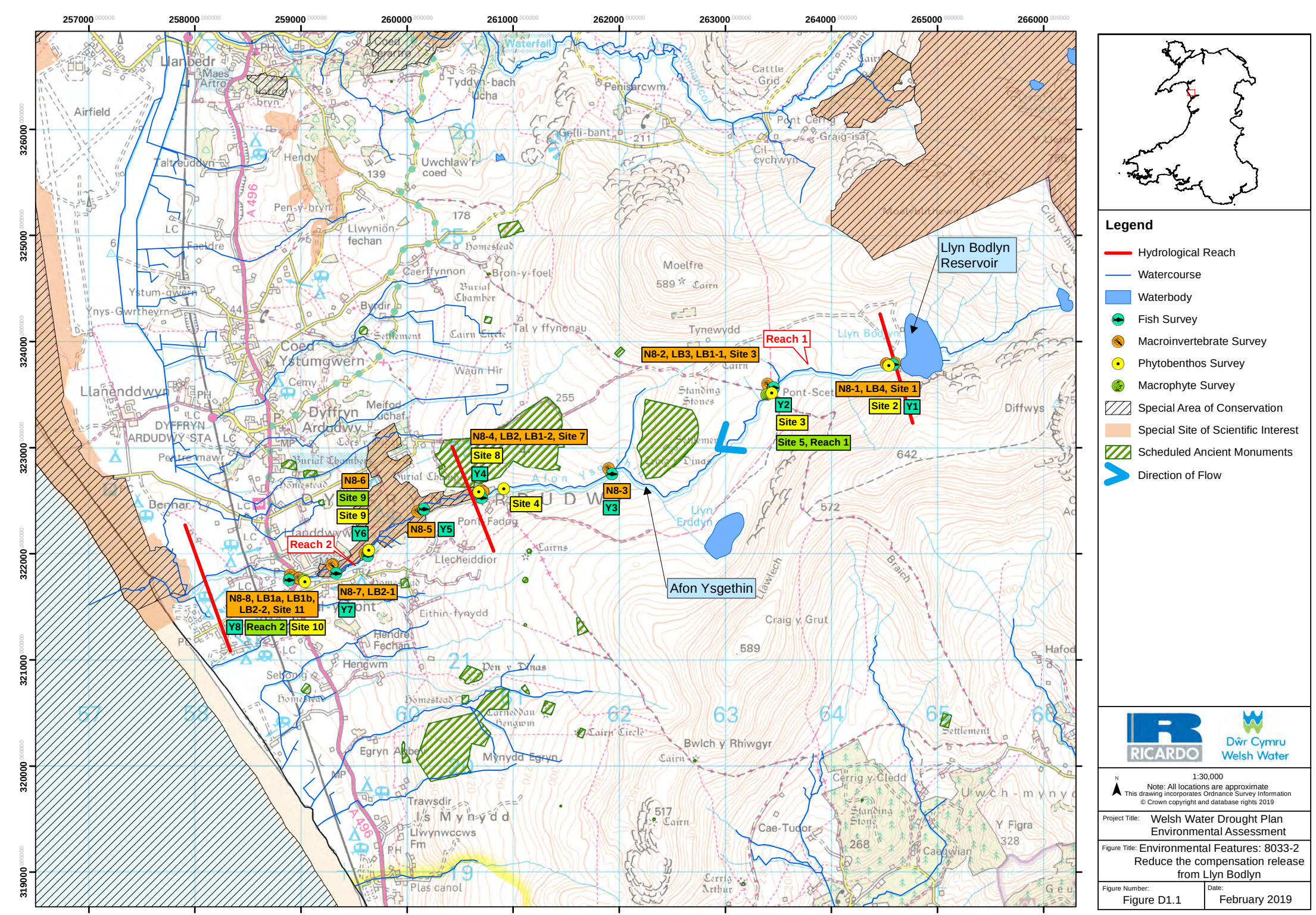
The assessment of environmental features is informed by the assessment of the physical environment (which includes hydrology and hydrodynamics; geomorphology; and water quality), this is summarised in Section 4 presented in full in **Appendix B**.

The ecological assessment has been undertaken recognising the IEMA[1][2] and the CIEEM study guidelines[3]. The assessment of impacts on other environmental receptors e.g. recreation and landscape has been carried out largely by qualitative expert judgement. Specific assessment methodologies for key environmental features are set out in **Appendix C**.

Desk-based assessments have been completed for each of the sensitive receptors, where applicable, in order to determine the magnitude of impact in the relevant river reaches for the Llyn Bodlyn drought order. Each feature assessment describes the analyses carried out and a statement of the assessed impact. All impacts are considered to be negative / adverse unless otherwise stated in the feature assessment.

This appendix is set out in the following sections:

[1] IEMA (2004) Guidelines for Environmental Impact Assessment.
[2] IEMA (2011) Special Report – The State of Environmental Impact Assessment Practice in the UK
[3] CIEEM (2016) Guidelines for Ecological Impact Assessment in the UK and Ireland.


Llyn Bodlyn Reservoir
Reach 1
N8-2, LB3, LB1-1, Site 3
N8-1, LB4, Site 1
Site 2
Y1
Y2
Site 3
Site 5, Reach 1
N8-4, LB2, LB1-2, Site 7
Site 8
Y4
Site 4
N8-3
Y3
N8-6
Site 9
Site 9
Y6
N8-5
Y5
Reach 2
N8-8, LB1a, LB1b, LB2-2, Site 11
N8-7, LB2-1
Y7
Y8
Reach 2
Site 10
Afon Ysgethin
Legend
Hydrological Reach
Watercourse
Waterbody
Fish Survey
Macroinvertebrate Survey
Phytobenthos Survey
Macrophyte Survey
Special Area of Conservation
Special Site of Scientific Interest
Scheduled Ancient Monuments
Direction of Flow
RICARDO
Dŵr Cymru Welsh Water
1:30,000
Note: All locations are approximate
This drawing incorporates Ordnance Survey Information
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Project Title: Welsh Water Drought Plan Environmental Assessment
Figure Title: Environmental Features: 8033-2 Reduce the compensation release from Llyn Bodlyn
Figure Number: Figure D1.1
Date: February 2019

D2 DESIGNATED SITES

D.2.1 Meirionnydd Oakwoods and Bat Sites SAC / Coed Cors y Gredol SSSI

D.2.1.1 Baseline

The Afon Ysgethin flows through the Meirionnydd Oakwoods and Bat Sites / Coedydd Derw a Safleoedd Ystlumod Merion SAC and Coed Cors y Gredol SSSI.

Meirionnydd Oakwoods and Bat Sites SAC is a very large example of old sessile oak woods in north Wales, with an outstanding Atlantic flora of bryophytes and lichens. It also includes probably the most extensive area of alder *Alnus glutinosa* alluvial forest in north Wales. The site is also important for wildfowl. The site provides habitat for a number of Annex II species, including the Lesser horseshoe bat *Rhinolophus hipposideros*.

The Annex I habitats that are a primary reason for selection of the site are:

- Old sessile oak woods with *Ilex* and *Blechnum* (of which the bryophytes and lichen flora is of particular nature conservation interest on this site);
- Alluvial forests with *Alnus glutinosa* and *Fraxinus excelsior* (Alno-Padion, Alnion incanae, Salicion albae);
- Annex I habitats present as a qualifying feature, but not a primary reason for selection of this site are:
    - European dry heaths;
    - *Tili-Acerion* forests of slopes, screes and ravines;
    - Water courses of plain to montane levels with *Ranunculion fluitantis* and *Callitricho-Batrachion* vegetation;
    - Bog woodland.

Annex II species that are a primary reason for selection of this site:

- Lesser horseshoe bat (*Rhinolophus hipposideros*).

For the purposes of assessing the response of riparian bryophyte communities within the Coed Gors y Gedol SSSI / Meirionnydd Oakwoods and Bat Sites / Coedydd Derw a Safleoedd Ystlumod Merion SAC to reduced water levels and flow, Welsh Water commissioned baseline data collection though quadrat sampling in August 2018[4]. In all cases, a 20cm x 20cm quadrat was used and percentage cover of each species of bryophyte (mosses, liverworts and hornworts) present in each quadrat was recorded. Incidental cover of any lichens and higher plants in the quadrats was also noted.

Quadrats were sampled from three different riparian zones within Coed Gors y Gedol SSSI, defined in **Table D3.4**.

[4] Ricardo (2018) Llyn Bodlyn Drought Plan Environmental Monitoring Report 2018. Report prepared for Welsh Water.

Table D3.4: Description of the different riparian zones

Riparian zone	Description	No. of quadrats
Lower stream channel	Low rocks in the water, usually submerged.	10 randomly placed
Low to high water	Rocks and boulders between upper and lower water levels.	10 fixed and 10 randomly placed
Above high water	Banks and steep rock walls above the upper water level.	10 randomly placed

The location of fixed quadrats were as follows:

Fixed Quadrat no.	OS Grid Reference
1	SH 6066122581
2	SH 6060922582
3	SH 6055022559
4	SH 6042322519
5	SH 6028722480
6	SH 5997822306
7	SH 5990122281
8	SH 5979422223
9	SH 5969422104
10	SH 5964022020

The baseline monitoring broadly characterised the different riparian zones by distinctive species assemblages:

- The lower stream channel, where rocks are frequently submerged, is characterised by a limited community of predominantly flow-tolerant mosses. *Platyhypnidium riparioides*, *Sciuro-hypnum plumosum* and *Fontinalis squamosa* are all common, although many rocks are scoured by the flow and lack any bryophytes at all.
- Numerous rocks of varying size occur in the channel between upper and lower water levels and this zone supports more species. Frequently the vegetation cover on the rocks is incomplete and the bryophytes sometimes grow with the large foliose lichen *Dermatocarpon luridum*. *Sciuro-hypnum plumosum* remains very frequent and is often mixed intimately with *Thamnobryum alopecurum*, *Racomitrium aciculare* and small patches of *Lejeunea lamacerina*. Rocks in this zone also support occasional populations of *Grimmia hartmannii*, *Heterocladium wulfsbergii*, *Platyhypnidium lusitanicum* and *Porella pinnata*, all scarce or uncommon species.
- Quadrats sampled randomly from the banks above the upper water level show little consistency, which is unsurprising considering the variety of microhabitats there. Large woodland floor species are typical of dry mossy banks, including *Rhytidiadelphus loreus*, especially *T. alopecurum* and *Thuidium tamariscinum*. Flushed banks often support populations of *Hyocomium armoricum*

Populations of three Nationally Scarce species were found in the course of the survey. *Heterocladium wulfsbergii* was found to be frequent in the quadrats in the low to high water zone where boulders would be regularly, but not permanently submerged. *Platyhypnidium lusitanicum* was seen in only one place, on several rocks partly submerged in the riverbed at SH 60645 22587. *Porella pinnata* also appeared to be relatively widespread in the surveyed river section, being found in five different places, and occurring in a few of the quadrats. *H. wulfsbergii*, *P. lusitanicum* and *P. pinnata* are all Oceanic species[5] and are members of the Environment Act (Wales) Section 7 *Oceanic Ravine Assemblage* of bryophytes.

The surveyed section of Afon Ysgethin in Coed Gors y Gedol SSSI is rich in humidity-demanding bryophytes and supports populations of nine other Section 7 *Oceanic Ravine Assemblage* of bryophytes including: *Bazzania trilobata*, *Fissidens bryoides* var. *caespitans*, *Hyocomium armoricum*, *Jubula hutchinsiae*, *Lejeunea lamacerina*, *Lejeunea patens*, *Plagiochila spinulosa*, *Saccogyna viticulosa* and *Scapania gracilis*

D.2.1.2 Assessment

The Meirionnydd Oakwoods and Bat Sites SAC core management plan reports that water courses of plain to montane levels with *Ranunculion fluitantis* and *Callitricho-Batrachion* vegetation are only present in the Afon Glaslyn which forms part of the Glaslyn SSSI (SAC unit 27). This is outside of the hydrological reach impacted by the Llyn Bodlyn drought order, and consequently no impacts on this feature of the SAC are anticipated.

SAC unit 12 is the relevant unit relating to the hydrological zone of influence and is designated for the Annex 1 habitat old sessile oak woods with *Ilex* and *Blechnum* which is a primary habitat for the SAC designation. This habitat type is not on the whole hydrologically dependant and therefore many elements are unlikely to be adversely affected by the drought order. However, sensitive assemblages of "Atlantic" species, which occur in the mist and splash zones of rivers, waterfalls and cascades, is a defining feature of this habitat type and the drought order therefore has potential to affect the SAC. More detail on the bryophyte communities of the site are provided in the designation for Coed Cors y Gredol SSSI and therefore the potential effects on these communities are discussed in this context below.

Bryophyte and lichen communities form an important part of the Coed Cors y Gredol SSSI habitat: the humid environment provided by the wooded banks of the Afon Ysgethin will support a specific sub-set of this community. Hydrological impacts on Afon Ysgethin within the SAC and SSSI (Reach 2) are expected to be moderate with a reduction in summer low (Q_{95}) and extreme low flows (Q_{99}) of 16.7% of and 20.4% respectively. Resultant changes in wetted width, splash and humidity have the potential to effect elements of the bryophyte and lichen community within the SAC/SSSI, although such effects are expected to be limited due to the already limited nature of splash and humidity occurring at low flows during drought. A reduction in compensation flow in the river as a result of the implementation of the drought

[5] Hill M.O. and Preston C.D. 1998. The geographical relationships of British and Irish bryophytes. Journal of Bryology 20: 127-226.

order is unlikely to have any *short-term* impact on the majority of the humidity-sensitive bryophytes in the SSSI as ambient humidity will be buffered to a certain extent by the woodland canopy over the river.

More vulnerable are those species whose natural habitat is close to the normal water level and which depend on periodic cycles of inundation and exposure. Lowering of water levels is likely to expose *P. lusitanicum* and *P. pinnata* for longer periods and this may cause colonies to shrink or retreat downwards. A lower compensation flow may also have similar impacts on the population of *H. wulfsbergii*, which also requires regular wetting via occasional submergence and splashing .As flows during a drought period would normally be low and therefore splash and humidity already naturally limited, the degree to which sensitive species such as Atlantic bryophytes are likely to be affected by the hydrological changes would be expected to be less than if mid-range flows were affected (as for e.g. abstraction for hydroelectric schemes).

Given the limited duration of the drought order it is expected that any effects on the bryophyte community would be reversed following return to the normal hydrological regime. The impact of the drought order on the Coed Corsy Gredol SSSI and Meirionnydd Oakwoods and Bat Sites SAC is, therefore, anticipated to be **minor**, adverse, short-term and reversible.

Summary

The potential impacts of the Llyn Bodlyn drought order on SAC and SSSI designated sites and species are summarised in **Table D2.1**. The impacts, and their magnitude, have been based on the hydrological impacts (see **Appendix B** and Section 4.2 of the main report), their influence on the physical environment (including geomorphology, water quality and likely habitat availability) (see Section 4.3 of the main report) and the sensitivities of the bryophyte community. The impacts presented in **Table D2.1** are restricted to Reach 2 and represent the worst case impacts of implementing a drought order, over and above the impacts potentially caused by a natural drought.

Table D2.1 Summary of Impacts on SAC and SSSI Designated Sites and Species

Feature	Impact	Significance of Impact
Reach 2 – Afon Ysgethin		
Meirionnydd Oakwoods and Bat Sites SAC	• Reduction in flows resulting in potential changes to splash zone and humidity affecting bryophyte and lichen communities associated with and immediately adjacent to the river.	**Minor**
Coed Corsy Gredol SSSI	• Reduction in flows resulting in potential changes to splash zone and humidity affecting bryophyte and lichen communities associated with and immediately adjacent to the river.	**Minor**

D3 WFD STATUS AND COMMUNITY ASSESSMENT / NOTABLE SPECIES

D.3.1 Macrophytes

D.3.1.1 Baseline

There are no historic macrophyte data available for the Afon Ysgethin from NRW. Macrophyte surveys were undertaken on behalf of Welsh Water in 2011[6], 2017[7] and 2018[8]. The surveys used the standard LEAFPACS survey method as set out in Water Framework Directive UKTAG (2008)[9]. Eight river sections were surveyed between 1 and 5 August 2011 and repeated between 17 and 21 October 2011. Further to this, two river sections were surveyed on 8 August 2017 and three river sections were surveyed between 23-24 July 2018.

Each survey section comprised 100 metre stretches of river and the aquatic macrophytes and macroalgae within the zone that is flooded for at least 50% of the year were recorded, with abundance scored on a 10-point scale. A number of physical parameters were also recorded.

Macrophyte results were provided using the standard LEAFPACS2 methodology[10] in accordance with the requirements of the Water Framework Directive (WFD). This methodolog1y is based on the principle that different combinations, quantities, and numbers of macrophytes are associated with different flow conditions and nutrient availability in a river. The LEAFPACS2 method assesses the condition of river macrophyte communities using data on presence and abundance of species and groups of species recorded during a standard survey comprising a 100m river section. These indices are briefly described below:

(i) River Macrophyte Nutrient Index (RNMI): an index of eutrophication (high scores indicate enriched conditions);

(ii) Number of macrophyte taxa which are truly aquatic, i.e. hydrophytes (NTAXA);

(iii) Number of functional groups of macrophyte taxa which are hydrophytes (NFG): an assessment of the structural diversity of the plant community; and

(iv) Percentage cover of all green filamentous algal taxa over the whole of the surveyed river sections (ALG).

The 2011 data collected by the August survey (undertaken within the optimal season for river macrophyte survey) provide a baseline from which assessment of impact can be made. The October 2011 survey was aimed primarily at assessing the broad changes to the structure of the plant communities, such as changes in algal levels. Vascular plants were recorded at the same level as in the August survey, although some species (such as Hemlock Water Dropwort *Oecanthe crocata*) were dying back. However, bryophytes were surveyed in less detail and

[6] Amec (2012) Environmental assessment of the Llyn Bodlyn Drought Order. Report prepared for Welsh Water.
[7] Apem (2018) Dwr Cymru Welsh Water Drought Plan Monitoring 2016 to 2018:Llyn Bodlyn, July 2018
[8] Ricardo (2018) Llyn Bodlyn Drought Plan Environmental Monitoring Report 2018. Report prepared for Welsh Water.
[9] Water Framework Directive – United Kingdom Technical Advisory Group (WFD-UKTAG) (2008). UKTAG river assessment methods, macrophytes and phytobenthos; macrophytes (river LEAFPACS). SNIFFER, Edinburgh.
[10] WFD-UKTAG(2014) UKTAG river assessment method – macrophytes and phytobenthos (River LEAFPACS2).

focused on species occurring at greater than 1% cover, although other species were recorded where observed. The survey was undertaken when river levels were high making movement around the river challenging in some sections. It also impeded a detailed survey of the bryophytes. Searching for smaller submerged species (such as *Fissidens* species and *Chiloscyphus polyanthus*) in the rapids was particularly difficult due to wading in fast flow and due to turbulence. Greater depth also reduced visibility in deeper stretches, particularly when the water was coloured by peat. This problem was further exacerbated by low light levels due to overcast weather.

Several scores are used in the LEAFPACS method to summarise the macrophyte data (WFD-TAG 2008). These comprise: River Macrophyte Nutrient Index (RMNI); River Macrophyte Hydraulic Index (RMHI); Number of aquatic taxa (N_ATAXA-R); Number of functional groups (N_RFG); and Algal cover (ALG-COV). Additionally, although it is not one of the standard LEAFPACS metrics, the cover of macrophytes, excluding algae, is also given. Metrics for the 2011 surveys are presented in **Table D3.1**.

Further baseline macrophyte data was collected for this waterbody in August 2017 and then July 2018. The 2017 survey consisted of the collection of macrophyte data from one 100m river section in Reach 1 and one 100m river section in Reach 2. 2017 survey locations and macrophyte survey results are detailed in **Table D3.2**. The 2018 survey consisted of three 100m river sections, including one control site, one survey section in Reach 1 and one survey section in Reach 2. 2018 survey results are detailed in **Table D3.3**.

Table D3.1 LEAFPACS scores for the Afon Ysgethin from surveys carried out in August and October 2011

Water body	Site	Reach	River type		RMNI		RMHI		No. of aquatic taxa		No. of functional groups		% Cover macrophytes		% cover Algae	
			8/11	10/11	8/11	10/11	8/11	10/11	8/11	10/11	8/11	10/11	8/11	10/11	8/11	10/11
Afon Ysgethin	N8/1	1	DXe	DXe	3.9	3.7	4.6	4.6	13	11	5	5	20	20	50	60
Afon Ysgethin	N8/2	1	DXe	DXe	3.8	3.8	4.6	4.7	12	11	5	5	30	20	40	50
Afon Ysgethin	N8/3	1	DXe	DXe	4.4	4.5	4.9	5	15	14	5	5	10	10	60	50
Afon Ysgethin	N8/4	1	CVIIIa	CVIIIa	3.7	3.7	4.7	4.7	17	11	5	4	40	35	0	0
Afon Ysgethin	N8/5	2	CVIIIa	CVIIIa	4.2	4.2	4.9	4.8	8	8	3	4	30	30	0	0
Afon Ysgethin	N8/6	2	CVIIIa	CVIIIa	4.2	4.2	4.9	4.8	12	10	4	4	40	40	0	0
Afon Ysgethin	N8/7	2	CVIIIa	CVIIIa	4.2	4.2	4.8	4.8	13	12	6	6	40	40	1	0.1
Afon Ysgethin	N8/8	2	CVIIIa	CVIIIa	4.4	4.6	4.9	5	15	15	6	6	50	50	0.5	3
Afon Cefna	Control 1			CVIIIa		4		4.8		13		6		40		5
Afon Cefna	Control 2			CVIIIa		4		4.7		12		5		15		<0.1
Afon Arto	Control 3			CVIIIa		4.8		5.2		9		5		40		1
Afon Arto	Control 4			CVIIIa		4.4		5		17		6		40		3

The RMNI scores varied from 3.7 to 4.6 which are indicative of a macrophyte community associated with low levels of nutrients. There is an overall trend for increasing RMNI scores with sites further downstream. The scores were comparable for both August and October surveys.

The RMHI scores for the Afon Ysgethin were in the range 4.6 to 5.2, this is indicative of a macrophyte community associated with fast flows. The RMHI scores were comparable at all sites within both impacted reaches.

The number of aquatic taxa recorded ranged from 8 to 17 and was variable between survey locations. The area with the greatest macrophyte diversity was recorded in a diverse bryophyte dominated community in an area of rapids.

The upper sections of the Afon Ysgethin in Reach 1 have high proportions of algal cover, a proportion of which is *Cladophera aegropila* with significant amounts of *Cladophera glomerata*. High proportions of algal cover are commonly associated with nutrient enrichment, however the low RMNI scores and the upland location with few sources of potential nutrient sources means that this is unlikely. Consequently, there is no clear reason for the high algal cover in Reach 1, particularly as the algal cover is greatly reduced in Reach 2 in the Coed Cors y Gedol valley.

Table D3.2 Macrophyte survey results, 2017

		Matrix				Environmental Variables	
Reach	**Site Location (NGR, downstream extent))**	**RMNI**	**NTAXA**	**NFG**	**ALG**	**Total % Cover of Macrophytes**	**Total % cover of filamentous algae**
1	SH 6345123558	4.05	9.0	5.0	19.20	85	80
2	SH 5902121794	4.01	4.66	3.0	0	25	0

A marked reduction can be seen in the total cover of macrophytes between Reach 1, at 85%, and Reach 2, at 25% in the 2017 survey, with a great difference in algal cover also seen between sites, with 80% cover of filamentous algae recorded in Reach 1 and no visible cover present in Reach 2. This is similar to previous macrophyte surveys collected in 2011, where higher proportions of algal cover were recorded in the upper sections of Reach 1.

The RMNI score remained relatively consistent between Reach 1 and Reach 2. However, a decrease in the NTAXA and the NFG can be seen from Reach 1 to Reach 2, from 9.0 to 4.66 NTAXA, and 5.0 to 3.0 NFG respectively.

Table D3.3 Macrophyte survey results, 2018

		Matrix				Environmental Variables	
Reach	**Site Location (NGR, downstream extent))**	**RMNI**	**NTAXA**	**NFG**	**ALG**	**Total % Cover of Macrophytes**	**Total % cover of filamentous algae**
1	Site 5 SH 63393 23500	3.47	17.00	7.00	0.55	20	1
2	Site 9 SH 59637 22033	4.36	12.00	5.00	0.00	40	0
Control	SH 71446 40956	3.68	14.00	5.00	0.05	40	<1

Similar to the 2017 survey, a higher NTAXA and NFG can be seen in Reach 1 in comparison to Reach 2, algal cover also remains higher in Reach 1. The total percentage cover of macrophytes, however differs in comparison to the 2017 survey, with total cover greatly reduced in Reach 1 and increased in Reach 2.

The RMNI score is also seen to decrease in Reach 1 and increase in Reach 2 in comparison to results collected in the 2017 survey. The 2018 RMNI score varies from 3.47 to 4.36, which is indicative of a macrophyte community associated with low levels of nutrients.

Scores for the controls site lay between the scores recorded for Reach 1 and Reach 2 for RMNI, NTAXA, ALG and percentage cover of filamentous algae, and are identical to scores recorded for Reach 2 for NFG and total percentage cover of macrophytes.

Notable Species

Several nationally scarce bryophyte species occur in and close to this river. *Porella pinnata* (nationally scarce) was recorded in several locations in 2018 in Coed Cors y Gedol. It grows particularly in the flood zone on the downstream side of protruding boulders, often quite low in this zone where it is frequently inundated. *Heterocladium wulfsbergii and Platyhypnidium lusitanicum* (nationally scarce) were also recorded in 2018. See Section D.2.1 for further details.

D.3.1.2 Assessment

The assessment of impacts on the macrophyte community should be considered in the context of the watercourse under baseline conditions. Baseline data indicate that the macrophyte communities in the hydrological zone of influence of the drought order are bryophyte dominated, adapted to high to moderate flow conditions. Reduction in flows could affect macrophyte communities in a number of ways:

- reduction in velocity favouring species adapted to slower flow conditions
- proliferation of filamentous algae due to decreases in velocity / increases in water temperature
- shading of macrophyte stands by epiphytic algae, due to decreases in velocity/increases in water temperature;
- desiccation of macrophyte beds due to reduced wetted width and water depth
- encroachment of marginal emergent species into the channel
- reduction or movement of the splash zone from where this usually occurs, both at the edges of the channel and around in-stream features such as boulders and exposed bedrock, leading to desiccation of species present within these areas, particularly bryophytes.

The additional minor risk of water quality deterioration associated with ammonia in Reaches 1 and 2 could encourage macrophyte growth and increase the occurrence of more opportunistic taxa, epiphytes and filamentous algae. In turn, this could affect macrophyte condition or potentially community composition if slower growing species or those that prefer lower nutrient conditions are outcompeted. There is already a high proportion of filamentous algae (*Cladophora* species) within Reach 1.

Hydrological impacts as a result of drought order implementation in Reach 1 are anticipated to be major adverse during the summer and autumn period, including a reduction of 46% of the summer low flows (Q_{95}) and summer extreme low flows (Q_{99}) with corresponding reductions in wetted depths / wetted widths during the summer and autumn period. High flows which influence macrophyte community composition by scouring activities (particularly in late autumn and winter after the growing season) would not be affected.

Due to the potential extent of change to wetted area, velocities, splash and humidity during the main macrophyte growing season, operation of the drought order has the potential to affect

the condition, composition and extent of macrophyte communities. Low flows may also favour the proliferation of filamentous algae species due to changes in velocity and water temperature.

However, riverine bryophytes are generally well adapted to tolerate desiccation and rewetting and communities can take a long time to react to changes in environmental conditions[11]. Given the limited duration of the drought order it is expected that any effects on the macrophyte community would be reversed following a return to the normal hydrological regime. Therefore the impacts of the drought order on the macrophyte communities of Reach 1 are expected to be **moderate** adverse, short term, and reversible.

Hydrological impacts on Reach 2 are expected to be moderate with a lesser reduction in summer low and extreme low flows than Reach 1 (16.7% of the summer Q_{95} and 20.4% of the summer Q_{99}). The effects on the macrophyte community are likely to be similar to those in Reach 1 but of a lesser magnitude. The impact on the macrophyte community of this reach is considered to be **minor** adverse, short term and reversible.

Notable Species

Three Nationally Scarce bryophytes (*Heterocladium wulfsbergii, Platyhypnidium lusitanicum* and *Porella pinnata*) have been recently recorded at locations adjacent Reach 2 (see Section D.2.1.1). As flows during a drought period would normally be low and therefore splash and humidity already naturally limited, the degree to which sensitive species are likely to be affected by the hydrological changes would be expected to be less than if mid-range flows were affected (as for e.g. abstraction for hydroelectric schemes).

Given the lesser magnitude of hydrological change in Reach 2 through the Coed Cors y Gedol valley where more sensitive species are expected to occur and the limited length of the drought order, likely impacts of operation of the drought order on these species within Reaches 1 and 2 are assessed as **minor**.

Summary

The potential impacts of the Llyn Bodlyn drought order on the macrophyte community are summarised in **Table D3.4**. The impacts, and their magnitude, have been based on the hydrological impacts (see Section 4.2 of the main report), their influence on the physical environment (including geomorphology, water quality and likely habitat availability) (see Section 4.3 of the main report) and the sensitivities of the macrophyte community. The impacts presented in **Table D3.4** represent the worst-case impacts of implementing a drought order, over and above the impacts potentially caused by a natural drought.

[11] Demars, B. O. L. and Britton, A. (2011). Assessing the impacts of small scale hydroelectric schemes on rare bryophytes and lichens. Scottish Natural Heritage and Macaulay Land Use Institute Funded Report. Scottish Natural Heritage Commissioned Report No.421

Table D3.4 Summary of Impacts on Macrophyte Community

Feature	Impact	Significance of Impact
Reach 1 – Afon Ysgethin (Llyn Bodlyn Reservoir Outflow to Pont Fadog)		
Macrophytes	• Reduction in growth as a result of major impacts on water levels and flows. • Changes to community composition due to changes to flow rates and habitat loss due to reduction in wetted width. • Increase in filamentous algae levels due to increased nutrients or water temperature and decreased velocity.	**Moderate**
Reach 2 – Afon Ysgethin (Pont Fadog to tidal limit)		
Macrophytes	• Reduction in growth as a result of moderate impacts on water levels and flows. • Changes to community composition due to changes to flow rates and habitat loss due to reduction in wetted width. • Increase in filamentous algae levels due to increased nutrients or water temperature and decreased velocity.	**Minor**
Bryophytes (including *Heterocladium wulfsbergii, Platyhypnidium lusitanicum and Porella pinnata)*	• Changes to inundation pattern and splash due to changes in flow • Increase in competition from filamentous algae due to increased nutrients or water temperature and decreased velocity.	**Minor**

The Afon Ysgethin water body (GB110064048830) has not been classified for macrophytes, but as moderate for overall biological status. There is a risk of short-term deterioration in biological status of the water body due to the drought order. Impacts of drought order implementation on the macrophyte communities of the impacted reaches have been summarised as minor to moderate adverse, short-term, temporary and reversible. Consequently, the biological status of the water body is considered to be at **moderate** risk of short term deterioration.

D.3.2 Macroinvertebrates

D.3.2.1 Baseline

Baseline macroinvertebrate surveys were completed on behalf of Welsh Water in 2012, 2016, 2016 and 2017. Eight sites along the Afon Ysgethin were sampled in April 2012 and October 2012[12]. A total of five sites were sampled in October 2016, two sites in Reach 1 and three sites in Reach 2. In 2017 four sampling locations were selected, two sites in Reach 1 and two sites in Reach 2. Sampling was completed on two occasions, with spring samples collected in May 216 and autumn samples collected in November 2016. In both 2017 and 2018, four river sampling locations were surveyed, consisting of two sampling locations per reach. Survey locations are detailed in **Table D3.5**.

[12] Cascade Consulting (2013) Environmental Monitoring Studies for the Llyn Bodlyn Reservoir (N8) Drought Order, Report prepared for Welsh Water.

Table D3.5 Macroinvertebrate survey locations and date of survey

Site	Reach	NGR	April 2012	October 2012	October 2016	May 2017	November 2017	August 2018
N8-1 / LB4 / Site 1	1	SH6460023800						
N8-2 / LB3 / LB1-1 / Site3	1	SH6340023600						
N8-3	1	SH6190022800						
N8-4 / LB2 / LB1-2 / Site 7	2	SH6070022600						
N8-5	2	SH6010022400						
N8-6	2	SH5960022000						
N8-7 / LB2-1	2	SH5930021900						
N8-8 / LB1a / LB1b / LB2-2 / Site11	2	SH5890021800						

Sampling was completed by following the standard NRW protocol involving a three-minute kick / sweep sample encompassing all the available instream habitats in proportion to their occurrence. These datasets were used to calculate a series of standard biotic indices: Biological Monitoring Working Party (BMWP) scores; Average Score Per Taxon (ASPT) scores; Lotic Invertebrate Flow Evaluation (LIFE); and number of taxa (NTAXA).

LIFE scores are used to assess how sensitive a macroinvertebrate community is to change in flow. Family LIFE scores are provided for all available data. See **Table D3.5** for interpretation of scores.

BMWP is primarily used to monitor the impact of organic water quality but also responds to other pressures such as habitat reduction, siltation and toxic pollutants. High BMWPs are associated with good water and habitat quality. Comparisons between sites with BMWP scores must be used with caution as change to river type can have considerable influence over BMWP score. ASPT is derived from BMWP and provides the average BMWP sensitivity score of all the taxa found in the sample's macroinvertebrate assemblage. This index provides a more reliable means of comparing macroinvertebrate community quality between sites whilst also reducing the influence of sampling artefacts such as variable sampling effort. As such ASPT is used as the primary means of assessing macroinvertebrate response to water quality in this assessment. As a guide ASPT scores above 5 represent macroinvertebrate communities living in good water quality. Scores below 5 indicate water quality stress on the macroinvertebrate community.

Table D3.6 Interpretation of Macroinvertebrate Community LIFE Scores

LIFE score	Invertebrate community flow sensitivity
7.26 and above	High sensitivity to reduced flows
6.51 – 7.25	Moderately sensitive to reduced flows
6.5 and below	Low sensitivity to reduce flows

Scores for sites surveyed in 2012 can be found in **Table D3.6**, scores for surveys completed in 2016-17 can be found in **Table D3.7** (2016) and **Table D3.8** (2017).

Table D3.6 Total taxa, BMWP scores, scoring taxa and ASPT scores for sites surveyed in 2012.

Site	Total Taxa		BMWP		Scoring Taxa		ASPT	
	Apr-12	Oct-12	Apr-12	Oct-12	Apr-12	Oct-12	Apr-12	Oct-12
N8-1	7	6	21	25	5	6	4.20	4.17
N8-2	10	16	41	82	8	15	5.13	5.47
N8-3	24	7	121	28	18	6	6.72	4.67
N8-4	19	14	93	80	14	13	6.64	6.15
N8-5	21	7	110	30	15	6	7.33	5.00
N8-6	17	10	96	56	13	9	7.38	6.22
N8-7	20	8	103	49	15	8	6.87	6.13
N8-8	23	11	114	57	17	10	6.71	5.70

A total of 43 different species were recorded in April 2012 compared to 30 in October 2012. In general, BMWP Scores and the number of taxa were lower in the October samples (BMWP Score range 25-82) compared to the samples taken in April (BMWP Score range 21-121).

Species which will be most sensitive to abstraction are the LIFE Flow Group I species:

- Stoneflies – *Dinocras cephalotes*, *Perla bipunctata*, *Isoperla grammatica, Chloroperla tripunctata Chloroperla torrentium*.
- Mayflies – *Ecdyonurus dispar, Electrogena lateralis, Rhithrogena semicolorata.*
- Caddisflies –*Rhyacophila dorsalis*, *Silo pallipes*, *Odontocerum albicorne*.

The macroinvertebrate community of the Afon Ysgethin was dominated by the larvae of aquatic insects with nine different species of stonefly found, with both species of *Chloroperla* recorded and both large Perlidae *Dinocras cephalotes* and *Perla bipunctata.* There were six species of mayfly found and 13 species of caddisfly. There were few species of water beetle and molluscs recorded with no crustaceans found.

LIFE scores in the Afon Ysgethin were comparable between all sites with a range from 7 to 8.87. These scores are in the upper values of the range of scores obtained for rivers in England during studies as part of the development of the LIFE index (typical scores were 7.5-8.5)[13]. The LIFE scores indicate the presence of macroinvertebrate families that are sensitive to abstraction. LIFE scores are relatively uniform upstream to downstream in the watercourse and fluctuate very little between seasons.

The ASPT scores within the Afon Ysgethin range from 4.17 to 7.38 which indicate a range of moderate to very good water quality with the presence of invertebrate families that favour clean water with high oxygen levels. The ASPT scores were lowest at sites 1 and 2, with scores between 4.17 and 5.47: this is indicative of macroinvertebrate communities associated with moderate water quality. The highest ASPT scores were recorded in the spring samples at sites 5 and 6 with scores of 7.33 and 7.38 respectively, which is indicative of very good water quality.

In general, BMWP scores of over 150 indicate very high water quality, scores of 100-150 indicate good water quality, and less than 100 indicate average water quality conditions. BMWP scores ranged from 21 to 121 with an average score of 69 across all samples. The BMWP scores for site 1 were low for both the spring and autumn samples, this corresponds with low numbers of invertebrate taxa during these samples. The remaining sites had BMWP scores from one of the survey visits indicating moderate to good water quality. BMWP scores overall were slightly reduced in the autumn samples compared to the summer samples, this is likely to be due to the differing detectability of some species at different points in their life cycle. Overall, the BMWP scores fluctuate greatly but are indicative of macroinvertebrate communities associated with average water quality in the Afon Ysgethin.

Sampling was undertaken in August and October 2011 using the standard kick sampling approach[14]. Following sieving (1cm mesh) in the field to remove coarse substrate and debris, the fine fraction was preserved and retained for analysis in the laboratory. The survey analysis results including BMWP, ASPT and LIFE scores are provided in **Table D3.5.**

[13] Extence, C., Balbi, D.M., Chadd, R.P. (1999). *River flow indexing using British benthic macro-invertebrates: a framework for setting hydro-ecological objectives*. Regulated Rivers Research and Management, 15: 543-74
[14] Amec (2012) Environmental assessment of the Llyn Bodlyn Drought Order. Report prepared for Welsh Water.

Table D3.5 Biotic indices for the aquatic macro-invertebrate surveys undertaken in August and October 2011

Site/Index	Y1	Y2	Y3	Y4	Y5	Y6	Y7	Y8
BMWP (summer)	40	84	83	95	101	90	112	120
Biological Quality (summer)	Moderate	Good	Good	Good	Very Good	Good	Very Good	Very Good
NTAXA (summer)	9	14	14	15	17	14	18	19
ASPT (summer)	4.4	6	5.9	6.3	5.9	6.4	6.2	6.3
LIFE (F) (summer)	8.3	8.2	8.4	8.4	8.0	8.6	8.3	8.3
BMWP (autumn)	101	126	118	125	80	87	96	139
Biological Quality (autumn)	Very good	Very good	Very good	Very good	Good	Good	Good	Very good
NTAXA (autumn)	17	21	19	19	12	14	15	21
ASPT (autumn)	5.9	6	6.2	6.5	6.6	6.2	6.4	6.6
LIFE (F) (autumn)	7.6	7.8	7.7	7.9	8	8	8	7.9

Analysis of the BMWP scores for August 2011 indicate that biological water quality is good or very good, with the exception of Site Y1 which was found to be moderate with a BMWP score of 40. This site is located immediately downstream of the Llyn Bodlyn outfall and noticeable build-ups of algae at and below the outlet were noted and may be responsible for (or co-symptomatic with) the reduced BMWP score. The Number of Scoring Taxa varied between 9 (site Y1) and 19 (Site Y8) with the number of taxa increasing progressively downstream. Using ASPT, Site Y1 has a low score of 4.4 compared with the downstream sites (Y2 to Y8) where scores varied between 5.9 and 6.4. Data for October 2011 showed a marked improvement with water quality indicated as good or very good over the entire reach. The most notable improvement was at Site Y1, just downstream of Llyn Bodlyn.

Surveys were undertaken by Apem on behalf of Welsh Water in 2016 and 2017. Macroinvertebrates were collected at sampling sites indicated in **Table D3.6** and **D3.7.** The assemblages of macroinvertebrates at the sampling locations included in these surveys, were typical of relatively fast-flowing, unpolluted, gravel-bottomed streams in Wales. The samples were relatively diverse in composition; numerically dominated by the nymphs and larvae of mayflies (Ephemeroptera), stoneflies (Plecoptera), caddisflies (Trichioptera) and non-biting midges (Chirononomidae) with blackflies (Simuliidae) also abundant in 2016. Many the species within the most numerically abundant groups are relatively sensitive to chemical water pollution and have preferences for relatively high current velocity (i.e. sensitive to low flows) and this was reflected in the values of the biotic indices.

Welsh Water commissioned Ricardo Energy and Environment to undertake sampling during dry weather in August 2018 (see **Table D3.8**).

Table D3.6 Biotic indices for the aquatic macro-invertebrate surveys undertaken in 2016

	LB3	LB4	LB2	LB1b	LB1a
Reach	1	1	2	2	2
Total no. of taxa	32	35	41	33	31
BMWP Score	138	118	175	140	135
ASPT	6.27	5.90	6.73	6.36	6.75
LIFE score (family)	7.95	7.11	7.68	7.62	7.95

Table D3.7 Biotic indices for the aquatic macro-invertebrate surveys undertaken in 2017

	LB1-1		LB1-2		LB2-1		LB2-2	
	Spring	Autumn	Spring	Autumn	Spring	Autumn	Spring	Autumn
Reach	1		1		2		2	
Total no. of taxa	40	36	46	31	49	20	40	39
BMWP Score	137	128	140	134	177	94	134	169
ASPT	6.23	6.10	6.36	6.70	6.818	6.71	6.09	6.50
LIFE score (family)	7.55	7.56	7.19	7.26	7.65	7.58	7.10	7.67

Table D3.7 Biotic indices for the aquatic macro-invertebrate surveys undertaken in 2018

	Site 1	Site 3	Site 7	Site 11
Total Taxa	23	28	26	22
BWMP	78	130	138	104
BWMP Taxa	16	22	20	17
ASPT	4.88	5.91	6.9	6.12
LIFE (family)	6.86	7.3	7.72	7.4
LIFE (no. of families)	14	20	18	15

D.3.2.2 Assessment

As the drought order will result in a reduction in river flows and velocities, it is likely that many of the flow sensitive taxa will be temporarily lost from the reach, including many stonefly, mayfly, and caddisfly taxa such as *Perlidae, Chloroperlidae, Heptageniidae, Rhyacophilidae,* and *Goeridae*. As the LIFE scores for the sites in Hydrological Reach 1 and Reach 2 indicated taxa sensitive to abstraction pressure, it is likely that in the short-term, this impact will modify the macroinvertebrate community with a loss of species which prefer fast flows and proliferation of invertebrates which favour slow flows.

Marginal habitats are the most sensitive to flow reduction, with many slow-flow favouring species such as molluscs utilising this habitat. Depending on the rate of flow reduction, species in these marginal sediments may become stranded and ultimately die.

The reduced flows could also result in a short-term change to composition of the substrate, with finer substrates potentially deposited, however this has been identified in **Appendix B**

as being unlikely due to the nature of the catchment and lack of sources of finer sediments.

The minor risk of impacts on dissolved oxygen has the potential to negatively impact the most sensitive taxa such as stoneflies which require high levels of dissolved oxygen. This may potentially alter the community composition due to loss of sensitive taxa and proliferation of tolerant taxa.

However, the duration of the drought order is relatively short, affecting only one or two seasons after which time the hydrological regime and associated environmental factors will revert to those currently seen under the normal operating regime. Macroinvertebrates have effective recolonization strategies and following return to the normal hydrological regime, communities are expected to recover relatively rapidly, through recolonization either by air or directly by downstream displacement from unaffected or lesser affected reaches or tributaries within the catchment.

Overall, considering the composition of the baseline macroinvertebrate community, the short-term, temporary and reversible hydrological impacts of the drought order and the effective recolonisation strategies of macroinvertebrate species, impacts are on the macroinvertebrate community are assessed as **moderate** for Reach 1 and **minor** for Reach 2.

Summary

The potential impacts of the Llyn Bodlyn drought order on the macroinvertebrate community are summarised in **Table D3.8**. The impacts, and their magnitude, have been based on the hydrological impacts (see Section 4.2 of the main report), their influence on the physical environment (including geomorphology, water quality and likely habitat availability) (see Section 4.3 of the main report) and the sensitivities of the macroinvertebrate community. The impacts presented in **Table D3.8** represent the worst case impacts of implementing a drought order, over and above the impacts potentially caused by a natural drought.

Table D3.8 Summary of Impacts on Macroinvertebrate Community

Feature	Impact	Significance of Impact
Reach 1 – Afon Ysgethin (Llyn Bodlyn Reservoir Outflow to Pont Fadog)		
Macroinvertebrates	• Reduction in species diversity as a result of the loss of flow-sensitive taxa. • Loss of marginal habitats and reduction in abundance and distribution of species utilising such habitats. • Reduction in species diversity and abundance as a result of reduced recruitment.	**Moderate**
Reach 2 – Afon Ysgethin (Pont Fadog to tidal limit)		
Macroinvertebrates	• Reduction in species diversity as a result of the loss of flow-sensitive taxa. • Loss of marginal habitats and reduction in abundance and distribution of species utilising such habitats. • Reduction in species diversity and abundance as a result of reduced recruitment.	**Minor**

The Afon Ysgethin water body (GB110064048830) has not been classified for macroinvertebrates but has moderate overall biological status. There is a risk of short-term deterioration in status of the biological status due to the drought order. Impacts of drought order implementation on the macroinvertebrate communities of the impacted reaches have been summarised as **minor** to **moderate** adverse, short-term, temporary and reversible. Consequently, the biological status of this waterbody is considered to be at **moderate** risk of short term deterioration.

D.3.3 Fish

D.3.3.1 Baseline

Welsh Water commissioned a fisheries monitoring programme on the Afon Ysgethin in 2016 (undertaken by APEM[15]). In 2011 and 2012, the Afon Ysgethin was subject to intensive fisheries monitoring as part of a programme of ecological surveys (as recommended in the Environmental Monitoring Plan for Llyn Bodlyn (N8)[16]) commissioned by Welsh Water to fulfil the first iteration of the 'Environmental Assessment of Llyn Bodlyn Reservoir Drought Order'[17] in 2012 and, subsequently, in preparation for the production of this environmental assessment. Fisheries monitoring was undertaken by HIFI in 2011[18], OHES in 2012[19] and Apem in 2016[20].

Fisheries monitoring has also historically been undertaken on the Afon Ysgethin by NRW. Relevant previous studies and recent fish survey data have been reviewed and analysed and a baseline summary is provided below.

Existing Data

The most recent fisheries monitoring programme undertaken by APEM in 2016 consisted of fully and semi-quantitative electric fishing surveys at four sites in Reach 1 and two sites in Reach 2. HIFI in 2011 and OHES in 2012 consisted of a suite of surveys in a study area providing adequate coverage of the predicted extent of hydrological influence of the proposed drought order. Monitoring consisted of standard electric fishing surveys at three sites in Reach 1 and five sites in Reach 2 of the Afon Ysgethin. Detailed methodologies are provided in the relevant reports[21,22].

Fish survey data from one site on the Afon Ysgethin were provided by NRW following a data

[15] Dwr Cymru Welsh Water Drought Plan Monitoring 2016 to 2018 - Llyn Bodlyn - July 2018
[16] Cascade (2007). Environmental Monitoring Plan for Llyn Bodlyn (N8). A report for Dŵr Cymru Welsh Water. June 2007.
[17] AMEC (2012). Environmental Assessment of Llyn Bodlyn Reservoir Drought Order. A report for Dŵr Cymru Welsh Water. January 2012.
[18] AMEC (2012). Environmental Assessment of Llyn Bodlyn Reservoir Drought Order. A report for Dŵr Cymru Welsh Water. January 2012.
[19] Cascade (2013). Environmental Monitoring Studies for the Llyn Bodlyn Reservoir (N8) Drought Order. A report for Dŵr Cymru Welsh Water. January 2013.
[20] Apem (2018) Dwr Cymru Welsh Water Drought Plan Monitoring 2016 to 2018: Llyn Bodlyn, July 2018
[21] AMEC (2012). Environmental Assessment of Llyn Bodlyn Reservoir Drought Order. A report for Dŵr Cymru Welsh Water. January 2012.
[22] Cascade (2013). Environmental Monitoring Studies for the Llyn Bodlyn Reservoir (N8) Drought Order. A report for Dŵr Cymru Welsh Water. January 2013.

request to inform this assessment. The site, referenced as Site 1, is located within Reach 2 (SH 59169 21806). Whilst the site has not been surveyed consistently across years by NRW (surveyed in 2009, 2010, 2012), HIFI and APEM surveys were undertaken at the site (site name Y8) in 2011 and 2016 respectively.

The fish element of the Ysgethin waterbody (GB110064048830) (designated as a Heavily Modified Waterbody) was not assessed for in 2009 but was assessed as being at high status in 2015 and 2018[23].

Data Limitations

Following the commission of six surveys undertaken in 2016 by APEM on behalf of Welsh Water, the temporal integrity of the available data has improved. However, a number of limitations remain, including the unavailability of some datasets (HABSCORE[24]) and the difference between analysis and reporting methodologies between the surveys limiting comparability. The available data are, however, sufficient to provide an understanding of the fish assemblage.

Species Composition

Three fish species have been recorded within the hydrological zone of influence on the Afon Ysgethin: Atlantic salmon *Salmo salar* (Environment Act (Wales) Section 7 and Habitats Directive Annex II species), brown/sea trout *Salmo trutta* (Environment Act (Wales) Section 7) and European eel *Anguilla anguilla* (Environment Act (Wales) Section 7 and IUCN Red List 'Critically Endangered').

Brown trout and European eel are ubiquitous throughout the Ysgethin catchment but the data suggest that Atlantic salmon are present only within Reach 2. Brown trout and eel were recorded at all surveys sites in Reach 1 and 2 in 2016, whereas salmon were absent. A single sea trout was recorded at the upstream end of Reach 2, highlighting their presence in the Ysgethin. The EMP suggests that the impassable nature of the gorge below Pont Fadog prevent migratory salmonids from reaching Reach 2. A less significant barrier to migration is also presented by the small weir at the most downstream HIFI/OHES fish monitoring site (located at grid reference SH 589 218).

The available data suggest that the Afon Ysgethin provides important spawning and nursery habitat for Atlantic salmon and brown/sea trout as well as good quality freshwater habitat for European eel.

No lamprey species *Petromyzontidae* have been recorded during any fisheries monitoring despite ad hoc sampling of suitable habitat by HIFI in 2011. In addition, no minor species were recorded.

[23] Interim cycle 2 2018 status - Based on Natural Resources Wales 2018 Cycle 2 Interim Classification Data - https://drive.google.com/file/d/14w17jL05sNuToVELqMCK_yc6DdHU7STb/view

[24] HABSCORE is a system for measuring and evaluating stream salmonid habitat features. It is based on a series of empirical statistical models relating the population size of five salmonid species/age combinations (0+ salmon; >0+ salmon; 0+ trout; >0+ trout <20cm; >0+ trout >20cm) to observed habitat variables.

Atlantic Salmon

The available data indicates that juvenile Atlantic salmon are intermittently present in the lower portion of Reach 2 only: the species are present at NRW Site 1 and HIFI/OHES Sites Y7 and Y8 only. Fry (0+) and parr (>0+) densities at NRW Site 1 and HIFI Site Y8 (similar location) are shown below (**Table D3.9**). Their absence in 2016 indicates the species has not spawned successfully in the Ysgethin in recent years.

Table D3.9: Salmon fry and parr densities and equivalent NFCS Grades[25] at NRW Site 1/HIFI Site Y8 (the same site)

Year	Surveyor	Reach	Salmon Fry Density (no/100m²)	Salmon Parr Density (no/100m²)	NFCS Grade	
					Salmon Fry	Salmon Parr
2009	NRW	2	1.3	4.3	E	D
2010	NRW	2	0.0	2.9	F	E
2011	HIFI	2	0.0	10.8	F	B
2012	NRW	2	5.9	0.0	E	F
2016	APEM	1 & 2	0.0	0.0	N/A	

Fry densities were poor (Grade F) or entirely absent between 2009 and 2016. Parr densities showed significant variation between years, ranging from absent to good (Grade B) between 2009 and 2016.

HABSCORE analysis undertaken by AMEC (2012)[17] showed that Atlantic salmon fry (0+) populations were significantly lower than predicted at Sites Y7 and Y8. Parr (>0+) densities were lower than predicted (but not significantly lower) at Site Y7, and higher than predicted at Site Y8. This suggests that habitat availability is not a bottleneck (or the reason for poor fry densities) in the lower Afon Ysgethin; however, a paucity of monitoring data precludes further assessment of other factors.

Brown / Sea Trout

The available data suggest that juvenile brown trout are present throughout the hydrological zone of influence with the species recorded in all monitoring locations and samples. The most recent data shows spatial variation amongst brown trout abundance in 2016, with the highest number of fish recorded at site Y2 in Reach 1 (n = 100). Fry, parr and adult life stages of brown trout were recorded at all six surveys sites in 2016, highlighting the suitability of habitats within the hydrological zone of impact to support the various life-stages of the species. A single sea trout was also recorded at the most upstream survey site in Reach 1 (Y4) located immediately downstream of the Pont Fadog gorge, most likely marking the upstream limit of migratory salmonids. Density measurements were only available for the two most upstream

[25] For salmonids, a grading system is used based on the original Fisheries Classification System called the National Fisheries Classification (NFC). The electric fishing data are analysed to produce a juvenile salmon and trout density score for each site, using average values from the early 1990s as a baseline. The proportion of sites falling into different salmon abundance Classes (A to F) provides a measure of the health of the juvenile salmon populations for each river. Sites are typically grouped into those that are at or above average (Classes A to C), below average (Class D) and well below average or fishless (Classes E or F).

survey sites (Y1 and Y2) in Reach 1 only. The density of fry at Y1 in 2016 measured 29.5 fish/100m², and 15.7 fish/100m² at Y2; both of which exceed those recorded at the downstream end of Reach 2 (**Table D3.8**). Data from monitoring undertaken by HIFI in 2011 suggest that fry (0+) densities were good to average (Grade B and C) in Reach 1 and average to poor (Grade C and D) in Reach 2. Parr densities at Y1 measured 22.7 fish/100m², and 14.5 fish/100m² at Y2. It should also be noted that adult brown trout were recorded throughout the survey sites in 2016.The density of fry and parr recorded at Y1 and Y2 in the upper reaches of Reach 1 highlight the importance of the upper reaches of the river as a nursey and development ground for the species.

Sites Y7 and Y8 were both average (Grade C). Data derived from the 2011 HIFI monitoring show excellent (Grade A) parr (>0+) densities at Sites Y7 and Y8, with densities at all other sites ranging excellent to average (Grades A to C).

Table D3.10: Brown/sea trout fry and parr densities and equivalent NFCS Grades at NRW Site 1/HIFI Site Y8 (the same site)

Year	Surveyor	Brown/Sea Trout Fry Density (no/100m²)	Brown/Sea Trout Parr Density (no/100m²)	NFCS Grade	
				Trout Fry	Trout Parr
2009	NRW	13.4	13.4	C	B
2010	NRW	8.6	7.1	C	C
2011	HIFI	12.1	22.2	C	A
2012	NRW	4.5	12.8	D	B

Analysis of HABSCORE data undertaken by AMEC (2012) found that densities of 0+ brown trout were higher (but not significantly) than predicted at all sites on Afon Ysgethin (Sites Y1-Y8) indicating better populations than expected given the available habitat. This suggests that the availability of fry habitat may be a bottleneck in the Afon Ysgethin.

The density of >0+ trout (< 20cm) at Site Y1 was lower than predicted, suggesting poorer populations than expected, but the population was not significantly lower. Populations of >0+ trout (<20cm) at Sites Y2-Y8 were higher than predicted but the observed populations were not significantly higher than would be expected.

Densities of >0+ trout (>20cm) were significantly lower than predicted at Sites Y3, Y4 and Y6. Densities of >0+ trout (> 20cm) were also lower, but not significantly, than predicted at five sites on the Afon Ysgethin (Y1, Y2, Y5, Y7 and Y8).

The HABSCORE results for parr suggest that populations are significantly below the carrying capacity of the available habitat at a number of sites. Habitat availability is therefore unlikely to be a bottleneck to this life stage of brown/sea trout and other factors are likely to be impacting the population.

European Eel

The available data suggest that European eel are present throughout the hydrological zone of influence. The most recent surveys in 2016 recorded both elver (juvenile life stage) and 'yellow' eel (larger sub-adult fish) throughout all six surveys sites, indicating they are able to migrate freely from the sea upstream to Llyn Bodlyn.

Ecological value of fisheries receptors

Atlantic salmon (an Environment Act (Wales) Section 7and Habitats Directive Annex II species), brown/sea trout (an Environment Act (Wales) Section 7) and European eel (an Environment Act (Wales) Section 7 and IUCN Red List 'critically endangered' species) are considered to be of National Importance.

D.3.3.2 Assessment

Hydrological variability in rivers can have a significant influence on the distribution of fish. When extreme low flows, or prolonged periods of low flow, are experienced (for example under continued water abstraction during drought conditions), the resultant changes in the hydrological regime can have significant impacts on resident fish communities. Abstraction of water from a river or stream reduces the wetted area and volume with the potential for subsequent impacts on fish populations as a result of, for example, intra- and inter-specific interactions (e.g. increased competition for optimal habitat and food)[26,27], reduced water quality and reduced reproductive success, growth and condition[28].

Potential impacts relating to habitat loss, water quality and migration are of relevance. These are discussed for key fish species in the sections which follow with particular focus on those aspects of fish ecology (e.g. migrations and juvenile life stages) most susceptible during the likely impact period April to November.

Flows in Reach 1 (the upper Afon Ysgethin above Pont Fadog) may be reduced by up to 46% due to the drought order and, whilst mortality under these conditions may be significant, fish species have evolved mechanisms in order to cope with low flow conditions, for example, avoidance behaviour (i.e. moving downstream as water levels drop) or the ability to persist in pooled areas of deeper water. However, flow sensitive species such as brown trout are, nonetheless, susceptible to reduced flows.

[26] Magoulick, D.D. (2000). Spatial and temporal variation in fish assemblages of drying stream pools: the role of abiotic and biotic factors. Aquatic Ecology 34, 29-41
[27] Davey A.J.H. & Kelly D.J. (2007). Fish community responses to drying disturbances in an intermittent stream: a landscape perspective. Freshwater Biology 52, 1719–1733.
[28] Magoulick, D.D. and Kobza, R.M. (2003). The role of refugia for fishes during drought: a review and synthesis. Freshwater Biology 48, 1186-1198.

Atlantic Salmon

Atlantic Salmon Migration

Whilst juvenile salmon densities recorded in the lower reaches of the Afon Ysgethin are low, the presence of both fry and parr life stages highlight the importance of Reach 2 as an important migratory pathway for the species (both upstream-migrating adults and out-migrating smolt). The majority of Atlantic salmon migration into the Afon Ysgethin is likely to occur from October to December and therefore a drought order being in place during October has potential to impact adult Atlantic salmon upstream autumn migration. Anecdotal data from angler catches in nearby catchments suggest that low numbers of early-running fish can enter the river from July if suitable periods of increased flow occur. This is likely to occur in a wet year (i.e. not a drought year) and early-running fish have therefore not been considered as part of this assessment.

The majority of out-migrating smolt would be likely to migrate between mid-March and mid-May depending on water temperature and there is therefore no potential for a drought order to interact with part of this migration.

The impact on river flow in Reach 2 has been assessed as being moderate adverse (Atlantic salmon are not present in Reach 1) and the impact on Atlantic salmon migration (adults) is considered to be of low magnitude, short-term, temporary and reversible. The impact on Atlantic salmon is therefore considered to be **minor adverse** in October in Reach 2 only, due to potential delays to migration and increased risk of stress and predation caused by a reduction in flow and suitable habitat.

Water Quality

Potential water quality impacts (e.g. reduced dissolved oxygen and increased water temperature) as a result of a reduction in flow are likely to act in tandem with a reduction in available habitat and delays to migration to increase stress and subsequent loss of condition. Atlantic salmon are susceptible to poor water quality and particularly suppressed dissolved oxygen levels and extremes of water temperature. Water quality impacts have been assessed as minor adverse in Reach 2 (Atlantic salmon are not present in Reach 1) and the impact on Atlantic salmon is therefore assessed as of low magnitude, short-term, temporary and reversible. The impact on Atlantic salmon is therefore considered to be **minor adverse** in Reach 2 only due to a potential reduction in water quality.

Juvenile Atlantic Salmon

There is the potential for reduced flow to result in a decrease in river levels and wetted width. There is therefore the potential for a loss or degradation of juvenile habitat along with gravel spawning habitat. Provided minimum low flows are available, juvenile Atlantic salmon are likely to relocate to areas of suitable habitat if river levels decrease, however, competition and stress would increase. Due to the likely timing of a drought order, gravels containing alevins and/or early-stage fry (likely to occur in April and May) will not be affected. The impact is therefore considered to be of medium magnitude in Reach 2 (Atlantic salmon are not present in Reach 1), short-term, temporary and reversible. The impact on juvenile Atlantic salmon is therefore considered to be **moderate adverse** in Reach 2 only.

Brown / Sea Trout

Sea Trout Migration

The lower reaches of the Afon Ysgethin (Reach 2) are likely to be an important migratory pathway for sea trout (both upstream-migrating adults and out-migrating smolt). The majority of upstream adult sea trout migration into the Ysgethin catchment is likely to occur from July to November, as supported by the presence adult sea trout recorded in August 2016, therefore a drought order in the period July to October has the potential to impact sea trout migration. Flow increases are a primary cue for adult sea trout migration and the magnitude and duration of periods of increased flow would be likely to be reduced as a result of a drought order. Minimum flows are also required in order for adult sea trout to navigate past barriers to migration such as weirs. Very low flows are likely to delay migration, thereby increasing mortality due to increased predation and stress.

The majority of out-migrating smolt would be likely to migrate between mid-March and mid-May depending on water temperature and therefore there is therefore no potential for a drought order to also interact with part of this migration period.

The impact on river flow in Reach 2 has been assessed as being moderate adverse (sea trout are unlikely to be present in Reach 1) and the impact on adult migration is considered to be of medium magnitude, short-term, temporary and reversible. The impact on sea trout migration is therefore considered to be **moderate adverse** from July to October in Reach 2 only due to potential delays to migration caused by a reduction in flow.

Water Quality

Potential water quality impacts (e.g. reduced dissolved oxygen and increased water temperature) as a result of a reduction in flow are likely to act in tandem with a reduction in habitat and delays to migration to increase stress and subsequent loss of condition. Brown/sea trout are susceptible to poor water quality and particularly suppressed dissolved oxygen and extremes of water temperature. The effects of reduced water quality are likely to particularly impact sensitive juvenile life stages. Water quality impacts have been assessed as minor adverse in Reaches 1 and 2 and the impact is therefore considered to be of low magnitude, short-term, temporary and reversible. The impact on brown/sea trout is therefore considered to be **minor adverse** in Reach 1 (brown trout only) and Reach 2 (brown and sea trout) due to a potential reduction in water quality.

Juvenile Brown / Sea Trout

There is the potential for reduced flow to result in a decrease in river levels and wetted width. There is therefore the potential for a loss or degradation of juvenile habitat along with gravel spawning habitat. Provided minimum low flows are available, juvenile brown/sea trout are likely to relocate to areas of suitable habitat if river levels decrease, however, competition and stress would increase. Due to the likely timing of a drought order, gravels containing alevins and/or early-stage fry (likely to occur in April and May) will not be affected.. The impact is therefore considered to be of high magnitude in Reach 1 and medium magnitude in Reach 2, short-term, temporary and reversible. The impact on juvenile brown/sea trout is therefore considered to be **major adverse** in Reach 1 and **moderate adverse** in Reach 2.

<u>European Eel</u>

Elver enter rivers in early spring and a general upstream migration occurs throughout the year. Elver migration is not linked to periods of increased flow and low flow conditions are unlikely to impact migration. In addition, juvenile eel have been recorded as recently as 2016 at the uppermost reaches of Reach 1, indicating their ability to pass freely throughout the hydrologically impacted reaches. The downstream migration of mature (silver) eel tends to occur between September and December in most rivers and there is therefore the potential for impact on the out-migration of mature European eel. European eel of a wide age range are present throughout the catchment, however, the species is tolerant of high temperatures and reduced water quality due to drought conditions. The impacts on European eel are therefore limited to silver eel migration and this is considered to be **moderate adverse** in Reach 1 and **minor adverse** in Reach 2 from September to October. Impacts on other European eel life stages are considered to be **negligible** in both reaches.

Summary

The potential impacts of the Llyn Bodlyn drought order on the fish community are summarised in **Table D3.11**. The impacts, and their magnitude, have been based on the hydrological impacts (see Section 4.2 of the main report), their influence on the physical environment (including geomorphology, water quality and likely habitat availability) (see Section 4.3 of the main report) and the sensitivities of the fish community. The impacts presented in **Table D3.9** represent the worst case impacts of implementing a drought order, over and above the impacts potentially caused by a natural drought.

There is a risk of short-term deterioration in status of the fish component of the Ysgethin waterbody (GB110064048830) due to the drought order. Impacts of drought order implementation on the fish communities of the impacted reaches have been summarised as minor to major adverse, short-term, temporary and reversible. Consequently, the fish component of this water body is considered to be at **major risk** of short-term deterioration.

Table D3.11 Summary of Impacts on Fish Community

Feature	Impact	Significance of Impact
Reach 1 – Afon Ysgethin (Llyn Bodlyn Reservoir Outflow to Pont Fadog)		
European eel	• Migration of silver eel	**Moderate** (September-October only)
Brown trout	• Reduced water quality	**Minor**
	• Reduction in spawning and juvenile survival due to habitat loss.	**Major**
Reach 2 – Afon Ysgethin (Pont Fadog to tidal limit)		
Atlantic salmon	• Delays and potential cessation of adult migration due to reduced flows.	**Minor** (October only)
	• Reduced water quality.	**Minor**
	• Loss of spawning and juvenile habitat as a result of reduced river levels.	**Moderate**
Brown / sea trout	• Delays and potential cessation of adult migration due to reduced flows.	**Moderate** (October only)
	• Reduced water quality	**Minor**
	• Reduction in spawning and juvenile survival due to habitat loss.	**Moderate**
European eel	• Migration of silver eel	**Minor** (September-October only)

D.3.4 Phytobenthos

D.3.4.1 Baseline

No baseline phytobenthos monitoring information was received from NRW for the reaches subject to hydrological impact. Welsh Water commissioned Ricardo Energy and Environment to undertake phytobenthos surveys in August 2018[29]. A total of six sites were sampled for phytobenthos on the Afon Ysgethin, three per reach, along with three control

[29] Ricardo (2018) Llyn Bodlyn Drought Plan Environmental Monitoring Report 2018. Report prepared for Welsh Water.

sites on the Afon Cynfal using the DARLEQ2 methodology30 (see **Table D3.12**).

Table D3.12 Phytobenthos surveys results 2018

Site	TDI4	EQR TDI4	Class TDI4
Site 2	18.4	1.0	High
Site 4	20.5	1.0	High
Site 6	21.3	1.0	High
Site 8	24.8	1.0	High
Site 9	27.4	1.0	High
Site 10	32.7	1.0	High
Control 1	17.7	1.0	High
Control 2	15.4	1.0	High
Control 3	27.0	1.0	High

D.3.4.2 Assessment

Impacts on the phytobenthos assemblages of the Afon Ysgethin could occur due to the operation of the drought order, including changes in community composition due to: decreases in velocity; changes to grazing pressure; increases in nutrient level; increases in water temperature; and increases in filamentous algae smothering the substrate.

Due to the short lifecycle of algal species, phytobenthos communities can respond to rapidly to environmental change. Therefore, the major and moderate hydrological effects of operation of the drought order in Reaches 1 and 2 respectively are likely to result in changes to the phytobenthos communities present within the timeframe of the drought order.

WFD EQR metrics for phytobenthos (TDI4 in DARLEQ)[31] are designed to detect differences in nutrient levels rather than other environmental factors and should not, in theory, be affected unless nutrient levels increase due to the operation of the drought order. However, it is recognised that other environmental factors can influence TDI4 scores (WFD-UKTAG, 2014) and potential changes to the micro-habitats supporting benthic phytobenthos growth are of such magnitude that there is potential for changes to the phytobenthos community to result in changes to EQR scores, resulting in a potential decrease in WFD ecological status in respect to phytobenthos.

Due to the rapid response of phytobenthos communities to environmental variables, this effect is expected to be short lived, with communities recovering rapidly following return to the normal hydrological regime, and therefore any effect of the drought order on WFD phytobenthos assessment is likely to be **minor (uncertain)** for Reaches 1 and 2. However, monitoring of phytobenthos communities within the affected reach would be required to fully assess the effects of the proposed drought order.

[30] UKTAG (2014) UKTAG River Assessment Method. Macrophytes and Phytobenthos; Phytobenthos (River DARLEQ2). July 2014
[31] WFD-UKTAG (2014) Phytobenthos: Phytobenthos for Assessing River and Lake Ecological Quality (River DARLEQ2)

Summary

The potential impacts of the Llyn Bodlyn drought order on the phytobenthos community are summarised in **Table D3.12**. The impacts, and their magnitude, have been based on the hydrological impacts (see Section 4.2 of the main report), their influence on the physical environment (including geomorphology, water quality and likely habitat availability) (see Section 4.3 of the main report) and the sensitivities of the expected phytobenthos community. The impacts presented in **Table D3.12** represent the worst case impacts of implementing a drought order, over and above the impacts potentially caused by a natural drought.

Table D3.12Summary of Impacts on Phytobenthos Community

Feature	Impact	Significance of Impact
Reach 1 – Afon Ysgethin (Llyn Bodlyn Reservoir Outflow to Pont Fadog)		
Phytobenthos	• Change in community structure due to decreases in velocity, changes to grazing pressure, increases in water temperature, and increases in filamentous algae smothering the substrate. Communities are expected to recover rapidly following return to the normal hydrological regime.	**Minor**
Reach 2 – Afon Ysgethin (Pont Fadog to tidal limit)		
Phytobenthos	• Change in community structure due to decreases in velocity, changes to grazing pressure, increases in water temperature, and increases in filamentous algae smothering the substrate. Communities are expected to recover rapidly following return to the normal hydrological regime.	**Minor**

There is a risk of short-term deterioration in status of the phytobenthos component of the Afon Ysgethin water body (GB110064048830) due to the drought order. Impacts of drought order implementation on the phytobenthos communities of the impacted reaches have been summarised as minor adverse, short-term, temporary and reversible. Consequently, the phytobenthos component of the Afon Ysgethin water body (GB110064048830) is considered to be at **minor (uncertain)** risk of short-term deterioration.

D4 LANDSCAPE AND RECREATION

D.4.1 Landscape

D.4.1.1 Baseline

The reach falls into the Meirionnydd area, a mountainous area with deep valleys, wide estuaries and extensive sandy beaches. The study area lies within the Snowdonia National Park and is of high overall landscape and visual amenity value. Llyn Bodlyn can be viewed from the hills in the upper catchment. There is a track that leads to the lake, but no marked footpath around the reservoir. There is a footpath along the top of the ridge to the east, from which the reservoir could be viewed. There are a number of footpaths crossing the Afon Ysgethin, although in the upper reach the footpaths do not follow the river bank. From Pont Fadog downstream, there is a footpath close to the river.

D.4.1.2 Assessment

A review of the hydrological implications of implementing a drought order has identified major hydrological impacts in Reach 1 and moderate hydrological impacts in Reach 2. The impacts include a significant reduction in surface water baseflow, wetted width and wetted depth beyond those observed in surface watercourses within the area of influence without the drought order. Landscape and visual amenity impacts may therefore be visible from public rights of way, footpaths, cycle routes and river crossings. However the impact on flows will only be temporary and will be ameliorated once the drought has passed. Flows during drought conditions will naturally be low therefore the implementation of the drought order is not expected to lead to any material additional landscape and visual amenity impacts and are assessed as **negligible**.

D.4.2 Recreation

D.4.2.1 Baseline

Recreational activities are primarily sports orientated with several canoeing, yachting, angling and diving clubs as well as a few outdoor pursuit centres. As the site lies within the Snowdonia National Park, the overall landscape and visual amenity of the area attracts walkers. All these activities provide a lucrative source of income for the area. However, the amenity value of the area in terms of access and facilities is generally considered to be low. Access for walkers is good along the lower Ysgethin, with a further footpath leading up to the reservoir. Other recreational activities include limited angling for brown trout and occasionally char at Llyn Bodlyn. Angling is also undertaken on the Ysgethin - the Harlech and Talsarnau District Angling Association has waters on this stretch of river.

D.4.2.2 Assessment

Major and moderate hydrological impacts have been identified in Reaches 1 and 2 on the Afon Ysgethin. Any reduction in wetted width and depth may influence water-dependent activities such as angling and canoeing. However, water levels will already be naturally low in times of drought and will already have curtailed these recreational activities prior to the drought order implementation. Any impacts will be temporary in nature and will be ameliorated once the drought has passed. Impacts are therefore assessed as **negligible** for Reaches 1 and 2.

D.4.3 Archaeology

D.4.3.1 Baseline

There are 3 scheduled ancient monuments present within Reach 1 which include a prehistoric hillfort (SH 62400 23000), a prehistoric enclosed hut circle (SH 60800 22900) and a prehistoric chambered long cairn (SH 60300 22800). Within Reach 2, there is a deserted rural settlement (SH 59900 21700) and a post-medieval/modern bridge (SH 63400 23500). There are numerous national historic monuments in the catchment area of Llyn Bodlyn and the Afon

Ysgethin. The vast majority of these relate to bridge remains, hut circles, sheepfolds, long huts and associated remains: these are not listed here due to their large number and lack of relation to the drought order activities in question. Other national historic monuments that are within the proximity of the reservoir or river are listed in Table D4.1. There are two old mills that would previously have been driven by water taken from the Afon Ysgethin, but neither mill has a working water wheel, so these have not been considered further. There are also three bridges crossing the Afon Ysgethin that are designated as national historic monuments. Since these cross the watercourse they could potentially be affected by changes to the watercourse and so have been considered in the assessment of effects. The right hand column of **Table D4.1** identifies which monuments have been taken forward for consideration in the assessment of effects.

Table D4.1 Historic monuments in proximity to Llyn Bodlyn and Afon Ysgethin

Name	Grid Reference	Potential to have some relation to hydrological changes in Llyn Bodlyn or downstream waterbodies
Numerous hut circles, sheepfolds, long huts	Many	No
Llyn Bodlyn peat mounds (N of Afon Ysgethin)	SH63852396	No
Llyn Bodlyn peat mounds (S of Afon Ysgethin)	SH64032361	No
Pont Scethin packhorse bridge	SH63442354	Possible (crosses Afon Ysgethin)
Pont Scethin peat stands and settlement	SH63392322	No
Pont Fadog	SH60732256	Possible (crosses Afon Ysgethin)
Glanafon (house)	SH5904621758	No
Tal-y-bont bridge	SH58952176	Possible (crosses Afon Ysgethin)
Tal-y-bont corn mill and house	SH58882184	No (remains of water wheel only)
Ty Isaf (dwelling)	SH589217	No
Pandy fulling mill	SH58552190	No (water wheel no longer in place)

D.4.3.2 Assessment

None of the scheduled ancient monuments identified in the features assessment have been identified as water dependent and water levels will already be naturally low in times of drought. Any impacts will be temporary in nature and will be ameliorated once the drought has passed. Impacts are therefore assessed as **negligible** for Reaches 1 and 2.

Summary

The potential impacts of the Llyn Bodlyn drought order on landscape, recreation and archaeology are summarised in **Table D4.1**. The impacts presented in **Table D4.1** represent the worst case impacts of implementing a drought order, over and above the impacts potentially caused by a natural drought.

Table D4.1 Summary of Impacts on Landscape, Recreation, Archaeology and Cultural Heritage

Feature	Impact	Significance of Impact
Landscape	• Landscape and visual amenity impacts may be visible from public rights of way, footpaths, cycle routes and river crossings. However the impact on flows will only be temporary and will be ameliorated once the drought has passed. • Flows during drought conditions will naturally be low therefore the implementation of the drought order is not expected to lead to any material additional landscape and visual amenity impacts	**Negligible**
Recreation	• Any reduction in wetted width and depth may influence water-dependent activities such as angling and canoeing. • Water levels will already be naturally low in times of drought and will already have curtailed these recreational activities prior to the drought order implementation. • Any impacts will be temporary in nature and will be ameliorated once the drought has passed.	**Negligible**
Archaeology	• None of the scheduled ancient monuments identified in the features assessment have been identified as water dependent and water levels will already be naturally low in times of drought. • Any impacts will be temporary in nature and will be ameliorated once the drought has passed.	**Negligible**